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This report is the documentation for a large-scale anti-air-warfareoriented computer simulation model designated SPEARS (System Performance Evaluation and Requirements Simulation). The model is, to the greatest extent practicable, machine and installation independent. The number of defensive and offensive units it can handle is limited only by available core storage.

(Continued)

20. ABSTRACT (Continued)

There are numerous applications for the model. Task force runs may be used to establish the relative effectiveness of the defense when changes are introduced in ship configurations (alternate radars or weapon systems) or in ship dispositions. Similarly the effects of changes in enemy attack tactics (raid size, weapon types, flight profiles, jamming levels, or target selection) are assessable. On a smaller scale, single-ship runs will allow the direct measurement of detection or firepower capabilities of an individual unit as changes are made in either the ship configuration or in the raid composition. The Track Data Handling System (TDHS) variant of the model offers a unique capabilities of operators to maintain accurate tracks and still be prepared to rapidly detect newcomers.

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SPEARS, AN AAW PERFORMANCE SIMULATION

1. INTRODUCTION

1.1 Background

This report is the documentation for a large-scale anti-air-warfare computer simulation model jointly developed at the Naval Warfare Research Center of Stanford Research Institute under the auspices of the Office of Naval Research (Code 462), the Office of the Chief of Naval Operations (NAVOP-962D1), and at the Radar Division of the Naval Relaboratory under the auspices of the Naval Ship Systems Command (Code 03521). There are two variants of the model, both of which will be described here. The versions of the model to which this documentation applies were completed in June 1973 and are designated SPEARS (System Performance Evaluation and Requirements Simulation).

1.2 Model Scope

The model is, to the greatest extent practicable, machine and installation independent. With the exception of two routines which use masking operations to pack and unpack integer data, the entire model is written in USA Standard FORTRAN*. The lengths of several packed lists and alphanumeric arrays depend on the word length of the computer being used; the procedure for properly dimensioning such lists is described in Appendix D.

The model capability for handling defense units (ships and AEW aircraft) and offense units (launch vehicles, standoff jammers, cruise missiles, etc.) depends on the availability of core storage in the user chosen computer. Appendix D describes the process of allocating core storage.

^{*} American National Standards Institute, Inc. USAS X3.9-1966.
Note: Manuscript submitted October 17, 1975.

The model belongs to the class of one-sided, event sequence Monte Carlo computer simulations. Enemy attack tactics are fully defined at the outset of a game situation by inputs to the Raid Generator, and the attack, thus specified, will be conducted during the play of the game. Therefore in this model the enemy will press his attack without regard to the extent of encountered losses, and surviving impacting weapons will remain assigned to ship targets as initially specified in the input values.

The event store structure of the model is a technique in common use for discrete simulations*. Significant types of "events," such as a radar detection event or missile assignment event, are defined, and a play of the game consists of a sequence of occurrences of such events. When the occurrence of an event is processed, it will cause the following sequence of actions to take place:

- 1. Evaluations peculiar to the event in question. For example the assessment of effects of an enemy weapon's impact would occur in the event DETONATE.
- 2. Changes in the lists that make up the data structure of the model. For example the alteration of the availability status of shipborne components would result from a FAIL event.
- 3. The generation of new events scheduled to be evaluated at a later time. For example the creation of a detection event may result from a radar scan event.
- 4. The removal of a previously scheduled event that has not yet been processed. For example the cancellation of a launch event would occur within a damage event which puts that launcher unavailable.

Scheduling a future event involves placing the event into a timeordered game calendar. A calendar entry consists of the type of event
desired, the game time at which it is to occur, and two integer paramaters that identify the units to which the event is applicable (such as
a radar set number and the number of a target just detected by the radar).
After the occurence of a particular event has been fully processed, the
simulation control routine will select from the game calendar that event
having the next time of occurence. This process will continue until the
end of the game play has been reached. In this model the end of game
time may be assigned by an input parameter, may be derived from the time
of last offensive weapon impact time, or may be determined by the game
calendar becoming empty.

^{*} G. Gordon, System Simulation, Prentice Hall, 1969.

At the conclusion of a play of the game, or replication, a statistical summary of significant event parameters is produced showing such items as the number of shots fired and kills achieved by each missile battery together with the average range of intercept, the number of detections produced by each radar and the corresponding average detection range, and the number of enemy weapon impacts suffered by each defense unit together with the resulting damage to its shipborne components.

This model is, loosely speaking, a Monte Carlo simulation by virtue of the random element used in generating several of the event types. For instance a cruise missile (termed a parasite when it is still aboard its launch vehicle or mother plane) may be launched within a specified time interval according to a uniform probability distribution; thereafter, the deviation of the actual speed of the cruise missile about a mean value is determined by sampling a normal probability distribution, the variance of which is specified on input; the aim point and impact point (relative to the targeted ship's position) of the cruise missile are determined from a bivariate normal probability distribution describing the aiming and guidance accuracies of the enemy weapon system. Other random phenomena include radar detections, missile-target intercepts, and damage assessment of enemy impacts, each of which involves Bernoulli trails with "success" or "failure" being determined by input or computed probability values.

The outcome of a single play, or replication, of a Monte Carlo simulation model is determined by the sequence of random numbers obtained from the random number generator. A second play of the same game situation with a different sequence of random numbers is likely to produce a different outcome. The importance of such differences depends on the purpose for which the analysis is being conducted. The number of replications required to achieve "sufficient" confidence in the measure of effectiveness of interest can be established only after some experience has been gained with applying the model to similar problems. To illustrate, the problem of determining the expected number of target kills achieved by an entire task force against a particular raid would probably require fewer replications than that of determining the expected number of target kills achieved by one of the ships within the force (both to the same confidence level).

The model itself is actually two separate computer programs. The first of these, known as the Pregame Processor (PGP), accepts inputs from punched cards and magnetic tape which completely describe a game situation, including the characteristics and positions of all offense and defense units. The PGP will, if desired, produce a listing of the input data available to it and the resulting composition of the opposing forces. With this listing an analyst may confirm that the situation described is exactly what is intended or take corrective action by revising the input card deck as appropriate. The PGP yields a game description on a magnetic tape file that may be used any time thereafter by the second portion of the model.

The second portion of the model, known as the Main Simulation Processor (MSP), uses the tape file produced by the PGP to execute the game as often as desired (as specified in the replication control input values). The MSP includes the actual event-store simulation model and a postreplication summary procedure. The type and extent of output listing produced during the play of a game are determined by the values assigned to various input parameters at the beginning of the MSP execution. If desired, the two portions of the model may be run back-to-back as a single computer job; this might be done whenever there is sufficient confidence that the input deck, or situation description, is error free.

1.3 Model Use

There are numerous uses for the model. Task force runs may be made to establish the relative effectiveness of the defense when changes are introduced in ship configurations (alternative radars or weapon systems) or in ship dispositions. Similarly the effects of changes in enemy attack tactics (raid size, weapon types, flight profiles, jamming levels, or target selection) may be assessed. On a smaller scale, single-ship runs may be conducted to measure more directly the detection or firepower capabilities of an individual unit as changes are made within the ship configuration or in the raid composition. Single-ship runs are often useful for gaining greater insight into observed or predicted differences in larger scale (task-force) runs.

The various simulation options available within the model permit investigation of the sensitivity of a game outcome to such factors as the level of detail to which the radar detection process is modeled or the degree of sophistication employed in defining missile time-of-flight characteristics. In certain instances it may be established that considerable running time may be saved through the use of the simpler algorithms at the expense of a negligible difference in the performance measures of interest.

1.4 The TDHS Variant

A major variant of SPEARS incorporates a Track Data Handling System (TDHS). This variant is at present not fully compatible with the main-line evolution of SPEARS. Nevertheless we consider it of sufficient importance to warrant documentation in this report. To distinguish clearly the TDHS description segments from those applicable to the rest of SPEARS, the parts of the report that refer to TDHS are placed in italics.

Many modifications were made to SPEARS in order to introduce detailed treatment of the Track Data Handling System (TDHS). A previous study* resulted in a description of the equipment and personnel which

^{* &}quot;AAW Track Data Handling System Description and Detector/Tracker Modeling Specifications" (U), SRI/NWRC Interim Report, Dec. 1971 (Confidential).

constitute the TDHS, together with specifications for modeling the detector/tracker (DET/TRK) operator function. In addition to the DET/TRK operator it has been found necessary to model many of the functions performed by the Track Supervisor (TRK SUP) so as to place the DET/TRK actions in proper context.

The TDHS is basically the command-and-control network which processes information available from the surveillance radars of a naval task force. As it is implemented in the Naval Tactical Data System (NTDS), the TDHS is a man-machine complex involving both data input functions (e.g., establishment and maintenance of target track histories) and data utilization functions (e.g., assignment of defensive weapon systems). At this time only the detection and tracking functions for a single ship (within the context of a larger force*) have been implemented in the simulation model; that is, the threat evaluation and weapon assignment (TEWA) functions for the defense force are not operating presently.

Growth potential for the TDHS version of the simulation model would be along two main directions: addition of the user functions (e.g., TEWA) to the present semi-single-ship configuration of the model, and expansion of the TDHS capabilities to all units within the force, including addition of the intership communication system used for data exchange.

The capability afforded by the TDHS version of the simulation model being described here is that for the first time in a large-scale AAW model target positions are uncoupled from radar video-return positions, which are in turn uncoupled from TDHS track-history data.

Until now the track updating function has been implicitly assumed to be performed instantaneously and without error in AAW simulation models. Differences between available large-scale AAW models have centered primarily on the algorithms used to determine the time (and in turn the position) at which each target becomes detected; these range from simple deterministic techniques to stochastic models in which single look detection probabilities are computed from "observed" signal-to-noise ratios. The SPEARS model incorporates several such algorithms from which the user may select in preparing inputs for a particular run.

However, as in all such models, target-position information subsequent to occurrence of initial detection is made readily available to potential users as long as the target remains in the coverage volume of the detecting radar. Tracking errors are not explicitly introduced, although small radar-measurement errors may sometimes be superimposed onto actual target coordinates.

^{*} Other ships in the force are included as part of the model input data solely for the purpose of providing a multi-ship environment against which enemy cruise missile targeting may be accomplished.

In the TDHS version of the simulation model, it is possible to observe and measure factors related to timeliness and accuracy of air tracks and to witness the effects of system saturation as the number of such tracks being maintained increases or as the countermeasures environment becomes more intense.

Numerous input parameters have been incorporated in this variant of the simulation model to describe the TDHS detection and tracking functions. Also several event types have been added to the game structure, and a summary table relating to TDHS performance has been added to the postreplication output listing.

1.5 Model Growth

SPEARS is available to users within the Navy community. The model will no doubt continue to be changed and expanded as time passes and as more experience is gained in applying the model to various analysis problems. Modifications to the model will be reflected in revisions to this document. Revised pages will be sent to any user who has requested and obtained a copy of the model itself as outlined above.

The authors of this report are available on a limited basis for consultation on problems related to compilation and execution of the simulation model. In turn we would appreciate being advised of any problems encountered in transferring the model to a different machine and of running times experienced under various situations.

Finally the authors of this report are interested in negotiating with potential sponsors for the development of the model's growth potentials and in some aspects of the conducting of analyses of naval AAW systems or subsystems through application of the simulation model.

2. OVERVIEW OF MODEL CONCEPTS AND ENTITIES

2.1 General

SPEARS is a detailed computer simulation of a defense oriented AAW battle. In this model the defense consists of a task force composed of stationary defense units such as ships and airborne early warning aircraft. Standoff jammers, aircraft launch vehicles, cruise missiles, and other airborne offense units form the enemy air attack. Defensive action against an incoming raid consists of launching surface-to-air missiles (SAMs) at establiched enemy tracks according to assessments of the threat posed to the task force by the attackers. The consequences of a defense strategy against a particular enemy assult may be observed in terms of the expected cost of the battle to the task force, taking into account the physical damage sustained by the defense units during the engagement as well as the amount of ordnance expended.

The simulation has been structured as an event sequence model where each significant occurrence or change in the progress of an AAW battle is accomplished through the execution of an event. As examples, the establishment of an enemy track, the launch of a surface-to-air missile against the track, and the interception of the track by the pursuing SAM are represented by DETECT, LAUNCH, and INTERCEPT events respectively. run of the simulation, or play of the game, consists of a progression through a time-ordered calendar of events, processing each event in turn. The execution of an individual event may generate one or more additional events to be inserted into the game calendar or cause currently scheduled events to be cancelled. An INTERCEPT event, for instance, may generate a DIE event for the intercepted track. The DIE event, in turn, clears the calendar of all pending assignments involving the track, thereby removing any LAUNCH or INTERCEPT events associated with the target. Game time at any point during the play is the time of occurrence of the event currently being processed. When two or more events are scheduled to occur at the same time, they are ordered into the game calendar according to a specified event-priority schedule.

Many events involved in the simulation are stochastic. For example the time of launch of an enemy air-to-surface missile (ASM) is considered a random variable with a uniform distribution over a specified time interval. When a missile is launched, the deviation of its actual speed about a mean value is determined by sampling a normal probability distribution with a prescribed variance. The outcome of each occurrence of a stochastic event depends on the set of values obtained from a random-number generator. In general an event-store simulation containing such events is labeled Monte Carlo to reflect this dependence on random sampling. Consequently a number of replications of the same game situation with different random-number sequences are necessary to obtain statistically significant estimates.

2.2 Enemy Platforms

2.2.1 Representation During Flight

Offensive unit motion within the simulation is described by a piecewise linear flight path. The points along the path at which changes in direction occur are called nodes, and a NODE event for the unit is scheduled to coincide with its arrival at each of these points. Only one NODE event for each active unit appears in the game calendar at any time; the occurrence of a NODE event reschedules the next NODE event, until the end of the flight path is reached. An important function of the NODE event is to determine any times at which the offensive unit on its current flight leg (current node to next node) will enter or leave the weapon assignment range of each active defense unit within the task force.

For nonimpacting targets the flight path may be described by up to 15 node points; the location of each such node and the speed of travel between each pair of nodes constitutes a portion of the Raid Generator inputs. Impacting targets, such as cruise missiles, may be assigned flight paths having one, three, or four legs with the speeds, altitudes, and climb/dive angles specified on input. The horizontal projection of an impacting weapon's flight path is a straight line from the launch position (defined relative to a reference node of the launch vehicle's flight path) to the impact point (in the vicinity of the assigned defense unit). Any enemy vehicle may employ ECM in the form of broad band barrage noise jamming on up to five radar frequency bands and on intership communications frequencies. Formations of enemy aircraft are easily described by defining in detail the flight path for one aircraft (the group leader) and specifying lateral, axial, and vertical displacements for each unit in the formation.

2.2.2 Enemy Weapon Impact

When an in-flight ASM, which is targeted on a ship in the task force, reaches its last NODE event (Fig. 2.2.2-1), an IMPACT event will be generated. The primary output of this event is the point in space where the ASM will detonate. This calculation is discussed in detail in Ref.l. Briefly, what happens is:

• The actual aim point of the ASM on the ship will be determined by perturbing the ASM from the intended aim point. This perturbation depends upon the flight path of the ASM, the projection of the ship on a plane normal to the ASM flight path, the reflection coefficient of the sea, and the reflection of the ship in the sea visible to the ASM (Fig. 2.2.2-2).

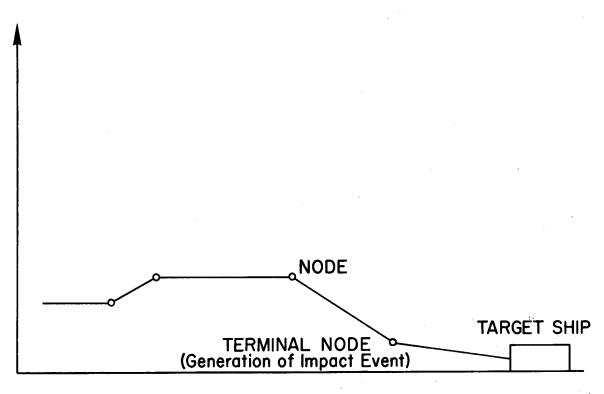


Fig. 2.2.2-1 - Profile of a missile flight path

- The projected intersection point of the ASM path with ship or ocean surface, whichever the missile reaches first, is calculated by adding a random error predicated on the ASM accuracy inputs.
- The prospective point of detonation is calculated by locating what position the ASM will hold at a user chosen post or prior distance from the missile intersection along the ASM path of motion.
- The event IMPACT or DUD is generated after a random number is drawn against the probability of an ASM dud.

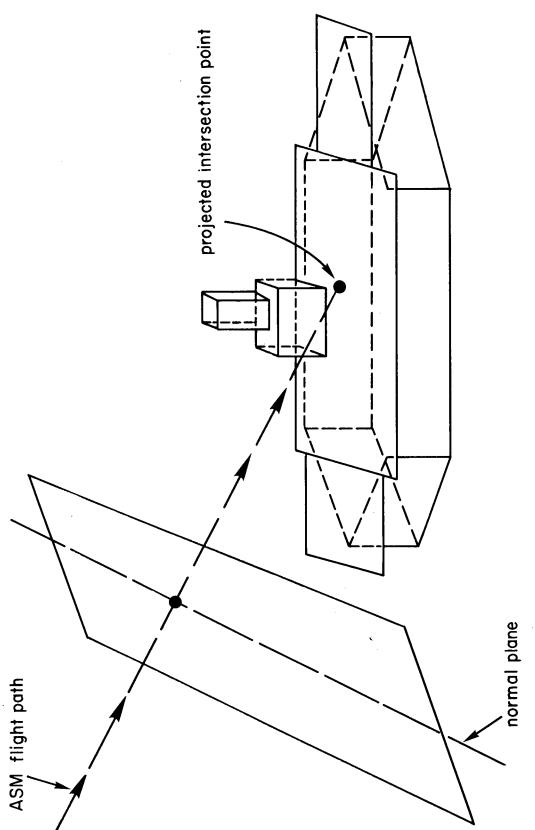


Fig. 2.2.2-2 - Model of an aircraft carrier

2.3 Surveillance Radar

SPEARS provides to the user several alternative methods for calculating if and when an enemy intruder is detected. Each individual radar in the defense has associated with it a user-chosen model option number.

All options have in common a sequence of events called SCAN's for each surveillance radar. These events specify the moments when detection is attempted by an individual radar on an individual target. The methods associated with the performance evaluation of a radar system triggered by a SCAN event are defined below, along with a description of the four current radar model options.

2.3.1 Radar Horizon

Using Fig. 2.3.1-1 to define a coordinate system, assume the observing radar is at (0,0,h). Then the target is below the horizon if and only if

$$z^{1/2} < \max \{ (D/95.2) h^{1/2}, 0 \},$$

where all quantities are in nautical miles.

2.3.2 Resolution Cells

Radar models options 3 and 4, to be defined in subsections 2.3.8 and 2.3.9, require the partitioning of targets into resolution cells. The input parameters necessary to describe this are

- Φ , minimum horizontal discrimination angle taken to be identical with the horizontal one-way, 3-dB-power beamwidth;
- \bullet 0 , minimum vertical discimination angle taken to be identical with the vertical one-way, 3-dB-power beamwidth;
- ullet Δ , minimum range discrimination;
- γ , mimimum closing speed discrimination.

The values of these parameters are used only if the radar involved has the particular implied discrimination.

Let φ , where φ $\epsilon[0,2\pi$), be the horizontal angle of the target as in Fig. 2.3.1-1 and define the apparent vertical angle above the horizon of a target to be

$$\theta = \arctan\{ z/D - [(D^{1/2}/95.2) - (h/D)^{1/2}]^2 \}, \theta \in [-\pi, \pi).$$

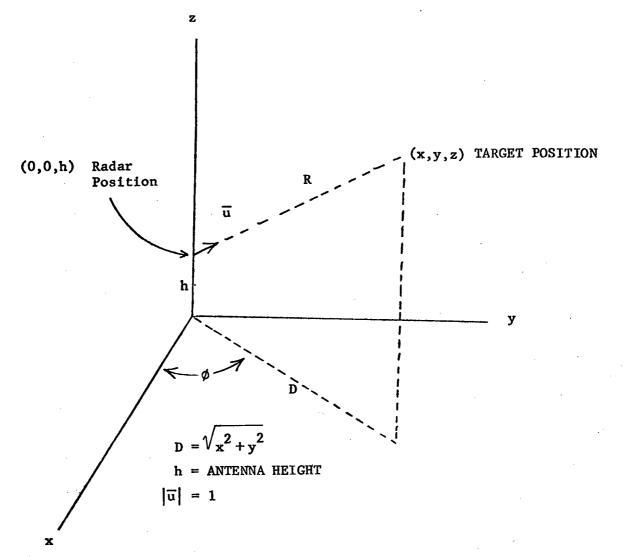


Fig. 2.3.1-1 Definition of target coordinates

Assume that the radar is traveling with velocity \overline{V}_R and that the target is traveling with velocity \overline{V}_T , consulting Fig. 2.3.1-1 for the definition of \overline{u} and R. Choose uniformly distributed angles ϕ_r and θ_r . Define the resolution coordinates Ω of a target as

$$\Omega = \left\{ \begin{array}{c} \overline{\left(\phi - \phi_{r}\right) \mod(0, 2\pi)} \\ \overline{\phi} \end{array} \right\} , \overline{\left(\theta - \theta_{r}\right) \mod(-\pi, \pi)} , \overline{\left(\frac{R}{\Delta}\right)}, \overline{\left(\overline{v}_{T} - \overline{v}_{R}\right) \cdot \overline{u}} \\ \overline{\gamma} \end{array} \right\}$$

where {A} is the largest integer not exceeding A.

Assume that there are N targets above the radar horizon. A parameter applying to a target when subscripted will refer to the target with that subscript. Targets j and k are said to be in the same resolution cell if and only if $\Omega_{.}=\Omega_{k}$. Since $\Omega_{.}=\Omega_{k}$ is an equivalence relation between j and k, the resolution cells form a partition of the set of targets. Assume that the partition consists of M sets B₁, B₂, ..., B_M. Then, if j \in B and k \in B_s, targets j and k are in resolution cell s. Define ϕ^* to be the horizontal angle to the center of the horizontal sector defining B_s, and define θ^* to be the vertical angle to the center of the vertical sector defining B_s. Define G as the set of all target numbers that are jamming on the frequency of the radar. Figure 2.3.2-1 provides an example of these definitions where for simplicity only Φ and Δ are applied.

2.3.3 Radar Cross Section

The radar cross section of each target is computed as a function of its aspect angle Ψ with respect to the radar, where

$$\Psi = \arccos \left(\frac{\overline{v_T} \cdot \overline{u}}{|\overline{v_T}|} \right)$$

2.3.4 Signal Energy

The expected signal energy E from a target is proportional to the mean cross section σ of that target and inversely proportional to R 4 . It is also proportional to the square of the one-way-power horizontal and vertical gain functions of the radar evaluated at the direction in which the radar is pointed. With C defined as the proportionality constant,

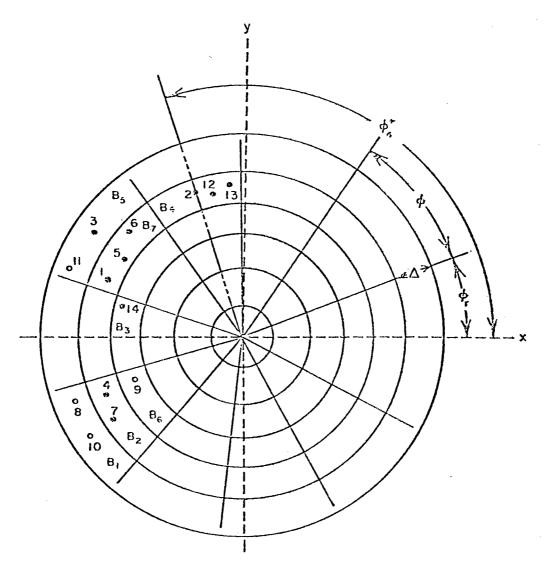
$$E = C_1 G_H^2 G_V^2 \sigma R^{-4}$$
.

2.3.5 Noise Energy

Define C₂ to be the receiver ambient noise.

The expected noise energy N from a broadband gaussian noise jammer is proportional to the rms noise energy J at the jammer, inversely proportional to R^2 , and proportional to G_H and G_V evaluated at the direction in which the radar is pointed. With G_M defined as the proportionality constant,

$$N = C_3 J G_H G_V R^{-2} .$$



- . NONJAMMING TARGET
- O TARGET JAMMING ON RADAR FREQUENCY

$$B_1 = [3,10]$$
 $B_6 = [9]$
 $B_2 = [4,7]$ $B_7 = [1,5,6]$
 $B_3 = [14]$ $G = [8,9,10,11]$
 $B_4 = [2,12,13]$ $N = [i3]$
 $B_5 = [3,11]$ $M = [7]$

Fig. 2.3.2-1 Partitioning of targets into resolution cells

2.3.6 Radar Model Option 1

At the time of the SCAN a target is declared detected by a radar if

- the target is within a specified maximum range of the radar,
- the target is within a specified horizontal angular sector specified about the radar, and
- the target is above the radar horizon of the radar.

2.3.7 Radar Model Option 2

At the time of the SCAN a target is declared detected by a radar if

- the conditions of Option 1 are satisfied and
- the target is within a specified vertical angular sector specified about the radar.

2.3.8 Radar Model Option 3

At the time of the SCAN a target is declared detected by a radar if

- the conditions of Option 2 are satisfied and
- \bullet a Monte Carlo trial based on a calculated probability of detection $\mathbf{P}_{\mathbf{D}}$ indicates a detection.

An outline of the calculation of the probability of detection ${\bf P}_{\bf D}$ is as follows. For target k the signal energy for 2D radars is

$$E_{k} = C_{1}G_{V}^{2}(\theta_{k})\sigma(\Psi_{k})R_{k}^{-4}$$

and for 3D radars is

$$E_{k} = C_{1}\sigma(\Psi_{k})R_{k}^{-4}.$$

The noise energy for 2D radars is

$$N_k = C_2 + C_3 \sum_{j=1}^{\infty} (j \in G) [J_j G_H (\phi_k - \phi_j) G_V (\theta_j) R_j^{-2}]$$

and for 3D radars is

$$N_k = C_2 + C_3 \sum_{j=1}^{\infty} (j \in G) [J_j G_H (\phi_k - \phi_j) G_V (\theta_k - \theta_j) R_j^{-2}]$$
.

The signal-to-noise energy ratio is

$$\rho_{\mathbf{k}} = E_{\mathbf{k}}/N_{\mathbf{k}} .$$

Then the probability of detection P $_{D}$ is calculated as a function of $\rho_{\bf k}$, the false alarm probability of the radar, and the number of pulses integrated for a detection decision. This is done under the assumption of a Marcum and Swerling type-3 target.

2.3.9 Radar Model Option 4

At the time of the SCAN, a target is declared detected by a radar if

- the conditions of Option 2 are satisfied and
- ullet a Monte Carlo trial based on a calculated probability of detection $\mathbf{P}_{\mathbf{D}}$ indicates a detection.

An outline of the calculation of the probability of detection P_D is as follows. Option 4 differs from Option 3 in that the signal energy is calculated for resolution cell s, summing over all targets in s rather than a single target k. Similarly, the noise energy for Option 4 is calculated with reference to the center of resolution cell s, represented by $(\varphi_s^*,\,\theta_s^*)$, rather than target position (φ_k,θ_k) as in Option 3.

For resolution cell s the signal energy for 2D radars is

$$E_{s}^{*} = C_{1} \sum_{k} (k \in B_{s}) [G_{V}^{2}(\theta_{k}) \sigma(\Psi_{k}) R_{k}^{-4}]$$

and for 3D radars is

$$E_{s}^{*} = C_{1} \sum_{k} (k \in B_{s}) [G_{V}^{2}(\phi_{k} - \phi_{s}^{*})G_{V}^{2}(\theta_{k} - \theta_{s}^{*})\sigma(\Psi_{k})R_{k}^{-4}].$$

The noise energy for 2D radars is

$$N_{s}^{*} = C_{2} + C_{3} \sum_{j} (j \in G) [J_{j}G_{H}(\phi_{j} - \phi_{s}^{*})G_{V}(\theta_{j})R_{j}^{-2}]$$

and for 3D radars is

$$N_s^* = C_2 + C_3 \sum_{j=1}^{\infty} (j \in G) [J_j G_H (\phi_j - \phi_s^*) G_V (\theta_j - \theta_s^*) R_j^{-2}]$$

The signal-to-noise energy ratio is:

$$\rho_s^* = E_s^*/N_s^* .$$

Then the probability of detection P is calculated as a function of ρ_s , the false alarm probability of the radar, and the number of pulses integrated for a detection decision. This is done under the assumption of a Marcum and Swerling type-3 target.

2.4 Characterization of a Defensive Weapon System

The specification of the battle scenario used to initiate the simulation includes a characterization of each defensive and offensive unit. The description of a defense unit includes a description of its weapon systems, each of which is modeled as consisting of a missile, a launcher, a missile magazine, and an associated missile guidance system. Although a unique association exists between launcher and missile magazine, a given missile guidance system may service a number of inidvidual launchers. To simplify bookkeeping within the simulation, a weapon component is classified by function (launcher, missile, or guidance) and by function type. For example, if seven launcher types are defined for the task force for a particular game play, the launcher configuration of any defense unit is specified simply by stating the type (from among the seven) and position of each launcher carried by the unit.

The following four sections are a description of the properties which characterize each of the four parts of a weapon system in this model. (A more complete discussion of these is found in Ref. 2.)

2.4.1 The Surface-To-Air-Missile

A SAM missile type is described by the following missile characteristics:

- minimum and maximum intercept ranges,
- performance envelope,
- time-of-flight data,
- lethality data,
- replacement cost.

2.4.1.1 Missile Intercept Range and Performance Envelope

The minimum and maximum missile intercept ranges together with the missile performance envelope define a solid of revolution about an origin, usually the position of the launcher, which may be interpreted as the set of points in space for which the probability of a SAM fired from the origin killing its assigned target is roughly the design constant. Outside this region, if a missile did intercept a target, a target kill would be unlikely. Therefore the model considers a missile for commitment to an established enemy track only when the projected point of intercept falls within the missile's performance envelope. Figure 2.4.1.1-1 illustrates a vertical-half-plane section of an example of a missile performance envelope with minimum and maximum missile intercept ranges.

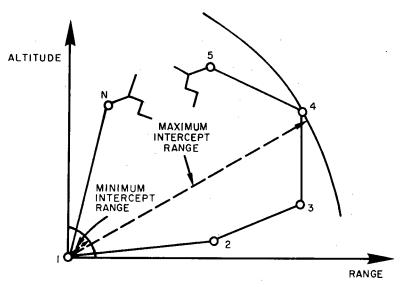


Fig. 2.4.1.1-1 - Vertical-half-plane section of a missile performance envelope

The fire zone sector is usually 360°, indicating full coverage, but it may be limited to any range by specifying a right-hand boundary with respect to the heading of the defense unit and the width of the desired section, measured in degrees counterclockwise from the right-hand boundary.

2.4.1.2 Missile Time of Flight

The length of time required for a missile to reach a given point within its performance envelope following launch is calculated from the missile's time-of-flight data. Figure 2.4.1.2-1 is an example of the type of information that may be inserted into SPEARS to represent missile time-of-flight.

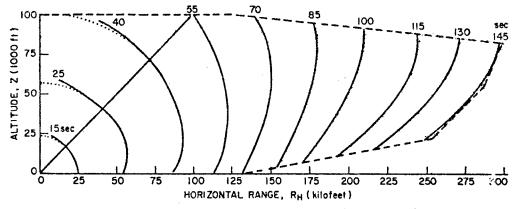


Fig. 2.4.1.2-1 - Missile time of flight as a function of horizontal range and altitude

2.4.1.3 Missile Lethality

The lethality of a missile type is interpreted in terms of the probability that a SAM launched against an enemy track scores a kill at the calculated time of intercept and in terms of the length of the subsequent time-to-die period experienced by the intercepted attacker. These values will vary according to the type of attacker intercepted, so each attacking unit in an enemy raid is characterized by an identifying vulnerability group index. The lethality data therefore for a given missile type consists of the specification of a probability of intercept and a probability distribution for the time-to-die random variable.

The time to die, defined as the length of time between intercept of an enemy unit and its actual demise, is considered to be a random variable with either an exponential or log-normal probability distribution, as indicated by the user.

2.4.1.4 Missile Replacement Cost

As implied, the missile replacement cost is the cost to replace a missile of this type.

2.4.2 The Launcher and Its Magazine

- A launcher type is defined by specifying the
- associated missile type,
- missile magazine capacity,
- number of rails,
- interrail firing delay,
- reload cycle time, and
- activation dalay.

In addition to the properties associated with its launcher type, each individual launcher carried by a defense unit is characterized by

- position and
- fire-zone sector.

2.4.2.1 Missile Type and Magazine Capacity

Each launcher is serviced by only its own missile magazine, which contains missiles of a single designated type. When its magazine is

emptied, the launcher becomes unavailable for the remainder of that play
of the game.

2.4.2.2 Launcher Time Delays

The interrail firing delay is the time between two successive shots from two fully loaded, adjacent launcher rails. The launcher activation delay is the time required by the launcher firing circuit to discharge a missile once it has been initiated. The reload cycle time is the time necessary to load all rails of an empty launcher.

2.4.2.3 Position

The position of a launcher is expressed in terms of the coordinate system for the local defense unit, where the center or specified position of the unit is taken as the origin.

2.4.3 The Missile Guidance System

A missile guidance system, capable of supporting at least one defensive missile-track assignment at any given time, is represented within the simulation by a collection of one or more constructs called guidance channels. Each guidance channel embodies the ability of the system to handle a single missile assignment. Physically a guidance channel might represent a director/illuminator tracking radar set as in a dualsimplex guidance scheme, where two such radars are used in conjunction with a single SAM launcher. In this situation a guidance channel is committed to a single engagement from track acquisition and missiel launch to intercept and kill evaluation, after which the channel is freed and available for reassignment. Thus a dual-simplex guidance system, with its two guidance channels, can handle at most two missiletrack engagements at any one time. In a more advanced system involving a multifunction-phased-array radar coupled with a computer the physical interpretation of a guidance channel is more difficult. As the multifunction aspect of the radar indicates, it may divide its time between surveillance, tracking, and the guidance of a number of simultaneous missile-track engagements. Each quidance channel then might represent the data-processing capability within the system required to guide a single missile.

A weapon guidance system is classified by weapon guidance group type, each group type being characterized by specifying:

- number of guidance channels in group,
- inflight guidance state vector,
- guidance constraint array.

2.4.3.1 Inflight Guidance State Vector

The rate at which data are transmitted between an active missile and its guidance system may vary as a function of the distance of the missile from its target and the time remaining before anticipated intercept and subsequent guidance release. A change in the data rate while the missile is in flight initiates a new missile guidance state. These transitions in guidance data rates are specified by means of an inflight guidance state vector whose components are the lengths of time, given in seconds, the missile spends in consecutive guidance states during the course of the engagement. Working backward from time of release the first entry in the guidance state vector denotes the kill evaluation period which commences upon missile track intercept and is terminated by the release of the guidance channel from the assignment. The second entry gives the time spent in the transition period immediately preceeding intercept. Each successive entry backs up in time to its predecessor and represents the time spent in a different guidance state.

A simple example is the case of a semiactive, homing-all-the-way missile system. Since no data rate transition occurs during the flight of such a missile, the inflight guidance state vector would contain a single entry, specifying the length of the kill evaluation period. Another example is a missile system having inflight initial, midcourse, and terminal homing guidance phases, where the initial phase remains unspecified, the midcourse phase lasts 40 seconds, the terminal-homing phase runs 15 seconds, and the kill evaluation time is 5 seconds. The corresponding inflight state vector would be

$$G = \begin{bmatrix} 5 \\ 15 \\ 40 \end{bmatrix} .$$

2.4.3.2 Guidance Constraints

The number of guidance channels available to a missile guidance system as represented by a guidance group places an upper bound on the number of missile assignments the system can process concurrently, However, physical characteristics of the hardware in the system and other considerations may dictate additional constraints on the number of missiles the system can handle in various stages of flight at any one time. For example, in the multifunction-phased-array radar system some restriction is necessary to reflect the physical limitation over time of the energy available to tracking and guidance as opposed to competing functions such as surveillance. These constraints are expressed by a system of guidance constraint equations, to be discussed below.

Define the initial state or state 1 of a missile-track assignment to be that period from time of assignment until time of launch. Let state 2 commence at time of launch and continue until the assignment enters the guidance period represented by the last entry (40 in the example of the preceding subsection) in the guidance state vector, which becomes state 3. The next to the last entry in the guidance vector is state 4, and so on. If the number of components in the guidance state vector is NSTATE, then the first component, the kill assessment period, represents state NSTATE + 2. Let

s_i(t) = number of guidance-group missile assignments
in state i at time t.

Then

$$S(t) = \begin{bmatrix} s_1(t) \\ s_2(t) \\ \vdots \\ s_{NSTATE + 2}(t) \end{bmatrix}$$
(2-1)

represents the guidance-group missile assignment vector at time t. Consequently the guidance-group constraints may be expressed by the system of inequalities

$$A S(t) \leq N_t C, \qquad (2-2)$$

where

A = constraint coefficient matrix (NROW by NSTATE + 2),

NROW = number of constraint equations,

S(t) = guidance-group missile assignment vector,

 N_t = number of active guidance channels in the guidance group at time t,

C = constraint vector (NROW by 1).

Any contemplated missile assignment must satisfy these constraint equations from the proposed assignment time through the calculated release time. Since potential-assignment constraint evaluations are made under the assumption that currently active channels will remain so for the

duration of the proposed assignment, any subsequent random failure or battle-inflicted damage experienced by one or more guidance channels will result in immediately more restrictive constraint equations (through the value of the parameter N_{\downarrow}) and may force premature termination of one or more currently held assignments.

As an example consider a hypothetical guidance system having a single midcourse guidance transition occuring 10 seconds prior to anticipated intercept and consider a kill evaluation period lasting 6 seconds. Let A denote the number of assignments at any given time in the assign phase (state 1), M the number of assignments in the midcourse phase (state 2), F the number of assignments in the terminal phase (state 3), and E the number of assignments in the evaluation phase (state 4). Assume the guidance constraints which must be satisfied throughout SAM flight time by the N guidance channels within the system to be

$$A + M + T + E < 8N$$

and

$$A + 3M + 7T + 2E \le 14N$$

The guidance constraint parameters for a guidance group representing this system are

NSTATE = 2

NROW = 2

$$G = \begin{bmatrix} 6 \\ 10 \end{bmatrix},$$

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 3 & 7 & 2 \end{bmatrix},$$

$$C = \begin{bmatrix} 8 \\ 14 \end{bmatrix}.$$

The guidance constraint equation (Eq. 2-2)) is

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 3 & 7 & 2 \end{bmatrix} \qquad \begin{bmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \\ s_4(t) \end{bmatrix} \leq N_t \begin{bmatrix} 8 \\ 14 \end{bmatrix}$$

where N_{\perp} is the number of active channels at time t.

2.5 The TEWA Event

2.5.1 Weapon System Availability

A weapon system within the simulation consists of a launcher, a missile magazine, and an associated missile-guidance channel. A launcher or a guidance channel is available for assignment at current game time t if it is active and not currently assigned to another task. In addition a launcher must also be loaded or possess a nonempty missile magazine. A launcher or guidance channel is considered active if it is operable and all game components on which it depends are operational. (The operability of game components and their functional dependence on one another are discussed in Ref. 3.) Thus a weapon system is available for assignment at current game time t if both a launcher with a nonempty magazine and at least one of the guidance channels within its associated guidance system are available for assignment.

If no weapons aboard the defense unit are currently available and will not become available within the current TEWA interval [t, t + re-evaluation delay], the TEWA event is rescheduled for the conclusion of the TEWA interval. If no weapon systems are currently available but one or more will become so during the current TEWA interval, a TEWA event is scheduled for the earliest time of weapon availability and the current TEWA event is terminated. If at least one weapon system is currently available for assignment and at least one active established hostile track is held by the unit, the feasibility of all possible available weapon-established track assignments is then determined.

2.5.2 Feasibility of Assigning a Weapon System to a Track

The assignment of an available weapon system to an established track is feasible if:

- the track is within the weapon assignment range,
- the assignment would not violate the weapon-system guidance constraints for the entirety of the system's commitment to the track.

For a given weapon system and established hostile track, the weapon assignment range is determined as in a preceding subsection using the missile maximum-range volume to ascertain the possibility of intercept. If intercept is not possible, then this weapon is removed from consideration for assignment to the given track during the current TEWA event. If intercept is possible within the missile maximum-range volume given weapon assignment at current time t, then the predicted point of intercept is checked for inclusion in the missile performance envelope. If this test is met, and if the point of intercept also falls within the launcher fire zone sector (360° in the usual case of full coverage), then the associated weapon-system guidance constraints are examined for possible violation at any time during the proposed assignment.

2.6 Threat Evaluation and Weapon Assignment (TEWA)

Evaluations of the threat posed to the task force by an incoming enemy air attack and subsequent decisions either to wait or to take immediate action against one or more detected attackers are made within recurring threat-evaluation-and-weapon-assignment events, but also depend on information generated by related event occurrences. The following subsections describe the approach used within the simulation to define simulation event types, determine when an established track is within weapon assignment range, establish the feasibility of a proposed weapon-track assignment, evaluate the threat of a hostile track, and choose appropriate defensive action in accordance with the measure of effectiveness adopted for the task force.

2.6.1 Event Types

Each significant change in the state of the system described by an event sequence simulation is represented within the simulation by an event, with a play of the game or run of the simulation consisting of a sequence of occurrences of such events. The execution of a single event in the simulation event calendar may change the value of an attribute of a game element, create or destroy an element, or initiate or terminate element activity. Each event in the AAW simulation is characterized by its event type, two event parameters, and the time at which the event is to occur. The event types defined within the model may be classified according to function into four general categories:

- target motion events,
- radar detection and tracking events,
- threat evaluation and weapon assignment events,
- kill, damage, and disablement events.

The event types involved primarily with threat evaluation and weapon assignment (TEWA) are listed below. Each event type is identified by name, two event parameters in parentheses, and a brief description of its function.

- TEWA (defense unit number, free parameter): Recurrent threat evaluation for subsequent weapon assignment by a specified defense unit.
- ASSIGN (guidance channel number, track number): Assignment of a specified SAM weapon system to an established track.
- LAUNCH (guidance channel number, track number): Launch of a designated SAM against an established track.
- INCPT (guidance channel number, track number): Interception of an established track by a SAM.
- RELEASE (guidance channel number, free parameter): Release of a specified weapon-quidance system from its current assignment.
- TRANSFER (guidance channel number, track number): Transfer of a specified SAM assignment to a new track prior to intercept of the old track.
- DROP (guidance channel number, track number): Termination of a specified SAM assignment prior to launch.
- ABORT (guidance channel number, track number): Termination of a specified SAM assignment while the missile is in flight.
- COMEIN (defense unit number, track number): Penetration of the weapon assignment range for a specified defense unit by the designated track.
- OUTGO (defense unit number, track number): Exit from the weapon assignment range for a specified defense unit by the designated track.

2.6.2 Weapon Assignment Range

Threat-evaluation-and-weapon-assignment activity within the simulation is initiated on the first appearance of an established track within the weapon assignment range of any task-force defensive unit. An enemy attacker is considered within weapon assignment range of a particular defense unit at a given time t if there exists at least one weapon system aboard the unit with missiles capable of intercepting the attacker on its current flight path were it to be assigned to that target at time t. The weapon assignment range is specified for a target-and-defense unit in terms of the earliest and latest times at which one or more defense unit weapon systems can be assigned to the attacker on its current flight path and achieve intercept. The weapon assignment range of each active defense unit in the task force in relation to a given target is determined during

each occurrence of a series of NODE events associated with the attacking unit.

For each missile type carried by the defense unit, an initial calculation is made to determine the points of penetration of the current offensive unit flight leg into the missile maximum-intercept-range volume.

If an offensive unit will enter and/or leave the weapon assignment range of a given defense unit during the current node-to-node time interval as indicated by the earliest and latest weapon assignment times calculated for the defense unit, the current NODE event schedules a COMEIN event and/or OUTGO event in the game calendar for the appropriate time or times. The execution of the COMEIN event flage the offensive unit to be within the weapon assignment range of the specified defense unit, and the execution of the OUTGO event marks its exit from the assignment range by removing this designation.

2.6.3 The TEWA Event

Task-force threat evaluation and weapon assignment (TEWA) takes place within recurring TEWA events scheduled for individual defense units. Associated with each defense unit are one or more TEWA reevaluation time delays which are specified as input during game initiation. These TEWA delays are used by the TEWA event to reschedule itself according to the outcome of eech TEWA event execution.

The initial TEWA event for a given defense unit occurs the first time an attacker detected by the unit enters its weapon assignment range. Recall that the penetration of a defense unit's weapon assignment range is signaled by the occurrence of a COMEIN event, independently of the detection status of the attacker with respect to the defense unit. Once initiated, the TEWA event for each defense unit becomes a recurrent event, rescheduling itself according to one of its several reevaluation time intervals.

TEWA event execution for a given defense unit begins with a determination of all active, established tracks held by the unit currently within its weapon assignment range. If none are found, then the TEWA event for this defense unit is rescheduled for current game time plus a TEWA reevaluation delay. If established tracks are within range, then the availability of weapon systems aboard the defense unit is assessed.

Associated with each guidance group is a guidance state vector whose NSTATE components are the lengths of time the missile spends in consecutive guidance states during the course of an assignment. The first component represents the full assessment period beginning with intercept and ending with guidance release, the second entry the guidance phase just prior to the anticipated intercept, the third component the preceding contiguous guidance state, and so on, with the initial guidance state immediately following launch not included in order to avoid the problem

of allowing the guidance state vector to specify the entire missile time of flight for every assignment with the weapon system.

State 1 of a missile assignment is defined to be the period from assignment until launch, state 2 the time from launch until the first data rate transition state as represented by the last entry in the guidance state vector, and so forth, with state NSTATE +2 being defined as the kill assessment period terminated by release of the assignment. Thus, as given by Eq. (2-1), the guidance-group missile-assignment vector is

$$s'(t) = [s_1(t), s_2(t), ..., s(t)_{NSTATE + 2}],$$

where

To evaluate the effect of the contemplated missile-track assignment on the system guidance constraints, the constraints are evaluated at each point in time during the proposed assignment period at which a change would occur in any component of the guidance-group missile-assignment vector. To illustrate this procedure, consider a hypothetical missile system with a guidance state vector

$$G = \begin{bmatrix} 4 \\ 9 \end{bmatrix}$$

and launchers with an assign-to-launch time of 3 seconds. Assume two missile assignments with associated guidance channels 1 and 2, and assume the following time schedules (game time) are currently in progress:

| | <u>channel 1</u> | channel 2 | | | |
|----------------------|------------------|---------------|--|--|--|
| Assignment | at 7 seconds | at 12 seconds | | | |
| Launch | 10 | 15 | | | |
| Midcourse transition | 31 | 46 | | | |
| Intercept | 40 | 55 | | | |
| Release | 44 | 59 | | | |

These schedules were calculated from the computed missile time of flight for each assignment and the guidance state vector. For instance, in the case of channel 2, an assignment contemplated for the then current game time t=12 anticipated a missile time of flight (launch to intercept) of 40 seconds. As assign-to-launch period of 3 seconds placed launch at t=15 and thus intercept at t=55. Using the first entry in the guidance state vector, release was set at t=55+4=59, and working backward from time of intercept with the second vector component gave a midcourse transition at t=55-9=46.

Let current game time t = 21 and the proposed missile assignment schedule be:

channel 3

| Assignment | at 21 seconds |
|----------------------|---------------|
| Launch | 24 |
| Midcourse transition | 32 |
| Intercept | 41 |
| Release | 45 |

Consider the state table presented as Table 2.6.3-1, constructed by combining the schedules of missile assignments 1 and 2 and proposed assignment 3 and then ordering the entries according to time. For any given time t the value of the guidance state vector

$$S'(t) = [s_1(t), s_2(t), s_3(t), s_4(t)]$$

can be computed readily from the state table (Table 2.6.3-1). For example, at the proposed assignment time and current game time of t=21 the assignment vector is

$$S'(21) = (1, 2, 0, 0),$$

since the proposed assignment would be in state 1 and current assignments 1 and 2 are both in state 2. However, the assignment vector need be tested under only the guidance constraints for each change during that period for which the considered assignment would be in effect for it is assumed the constraints are satisfied prior to current game time. The

Table 2.6.3-1 Hypothetical Time Schedule for Two Missiles

| Time(s) | | State Entered |
|---------|---------|--------------------------|
| 7 | 1 | (assignment - channel 1) |
| 10 | - 2 | (launch - channel 1) |
| 12 | 1 | (assignment - channel 2) |
| 15 | 2 | (launch - channel 2) |
| 21 | 1 | (assignment - channel 3) |
| 24 | 2 | (launch - channel 3) |
| 31 | 3 | (midcourse - channel 1) |
| 32 | 3 | (midcourse - channel 3) |
| 40 | 4 | (intercept - channel 1) |
| 41 | 4 | (intercept - channel 3) |
| 43 | 3 | (midcourse - channel 2) |
| 44 | release | (release - channel 1) |
| 45 | release | (release - channel 3) |
| 55 | 4 | (intercept - channel 2) |
| 59 | release | (release - channel 2) |

assignment vector values of interest then, as bracketed by arrows in Table 2.6.3-1 are

```
S'(21) = (1, 2, 0, 0),

S'(24) = (0, 3, 0, 0),

S'(31) = (0, 2, 1, 0),

S'(32) = (0, 1, 2, 0),

S'(40) = (0, 1, 1, 1),

S'(41) = (0, 1, 0, 2),

S'(43) = (0, 0, 1, 2).
```

Note the constraints need not be tested when the change in a component is due solely to the release of an assignment. If the constraints

$$A \cdot S(t) \leq N_t C$$

are not violated upon evaluation with each of the assignment vector S'(21) through S'(43), then the constraints are satisfied for the duration of the proposed missile-track assignment. (If the constraint matrix is generalized so that its elements are functions of game time t, then the verification of the constraint inequalities for the duration of the proposed assignment, while feasible, is more complicated.) Again, future attrition of currently active guidance channels could cause the constraints to be violated at a later time and result in the cancelation

of one or more currently held assignments. However, if the constraints are satisfied at this point for the proposed assignment period, the assignment is considered feasible and held for further consideration.

2.7 Vulnerability and Reliability of Defensive Units

2.7.1 The Need For Consideration

During the last decade much attention has been given to the assessment of the relative utility of various weapon systems employed in the defense of a naval task group under air attack. Although it is acknowledged that at least a few missiles might penetrate the group's defenses and thus erode its defensive capability, the precise manner in which this erosion should be incorporated into the utility function has remained an open question. SPEARS makes it possible to bring both the defensive capability and the vulnerability of the group's weapon system into one utility function.

2.7.2 The Utility Function

In SPEARS the amount of damage may be included in a global measure expressed as a cost having three terms. The first term is the cost of repairing (or replacing) all systems that are damaged during the battle and those systems that become inoperable because of random failures; the second, which is more subjective, is a cost reflecting mission capability to the fleet in terms of those systems that become inoperable for a period of time; and the third accounts for ordnance expended by the group during an engagement. Such a measure is a function of many variables, including the number of enemy air-to-surface missiles that penetrate the fleet's defenses, the number of vessels that become immobile during the battle, and the percent impairment of the fleet's defenses. Of course, the relative weighting of the different variables will depend on the mission of the group.

The defensive capability of the group is reflected in the utility function through estimating the cost of damage caused by each penetrating missile. This estimation is performed for each penetration at the time of detonation. In a parallel computation the model allows for the determination of those subsystems which have become inoperable. An operable system becomes inoperable through damage, random failure, or dependency on another aystem that has become inoperable. Moreover an inoperable system becomes operable through repair or replacement. As the game progresses, the operability states are altered as these system-oriented events occur. In each subinterval of time, the defensive capability of the fleet is assessed through an examination of all such operability states. It is through this mechanism that the damage sustained by the group is reflected in its defensive capability and thus in the utility function.

2.7.3 Approach To Problem

The characterization of the vulnerability of an element to detonations of enemy air-to-surface missiles is difficult. A detonation can be interior to the ship structure or exterior to the ship structure, and in the latter case the detonation can be in the air or beneath the surface. The vulnerability of an element to a particular detonation will depend on, among other things, the distance between the element and the detonation and the nature of the medium between the two. medium is important because it determines how the effects of the detonation propagate from the initial point to the element. One can envision the magnitude of computing the effects of the variety of media on the propagation of the detonation. In this model no attempt will be made to carry out such computations, the primary reason being that such computations are beyond the scope of this model and the secondary reason being that the knowledge of many aspects of these computations is sparse. However an attempt has been made to develop a characterization of the vulnerability of an element that will meet the following specifications:

- For a given detonation the characterization should yield the probability that the element is damaged, and, if the element is damaged, the characterization should yield the degree of the damage;
- The characterization should require only those inputs for which realistic approximations are available;
- The results obtained through the characterization should be consistent with results obtained through experimentation;
- The characterization should be sufficiently elementary to be used in conjunction with a large computer simulation.

As was indicated, a detonation and an element can be separated by many different media. The simplest case arises when the detonation occurs in the air, the element under consideration is exterior to the ship structure, and the element is in an unobstructed line of sight from the detonation. In this case a good measure of how the effects of the detonation propagate to the element is the peak overpressure at the element that is induced by the detonation. If the detonation occurs exterior to the ship's hull and beneath the surface, an accepted measure of the severity of the blast on an element at a given location is the keel shock factor. An empirical relationship exists between equivalent peak-overpressure and keel-shock-factor levels, two levels being equivalent when the expected amount of damage is the same.

The two cases most difficult to treat are the case in which the detonation occurs outside the ship in the air and the element is inside the ship structure and the case in which the detonation occurs inside the ship structure. However in this model it is assumed that for each detonation an estimate of the severity of the blast for each element aboard the ship is available and that this estimate is a function of the

size of the warhead being detonated, the distance between the detonation and the element, and the nature of the medium between the two points. Moreover it is assumed that regardless of the particular measure of the severity of the blast that is being employed an equivalent peak-overpressure level can be computed.

2.7.4 The Events

From a conceptual standpoint, all computations are partitioned into the areas

- damage assessment,
- random failures,
- estimation of costs,
- estimation of repair times, and
- treatment of dependencies.

These areas are treated within seven eventtypes:

- Event FAIL An element fails as a consequence of a random malfunction of that element. The game time at which a FAIL event occurs for an element is assumed to be independent of the on/off and up/down states of that element. If the element is operable when a FAIL event occurs, the element becomes inoperable, but if an element is down when the event occurs, the degree of inoperability of the element is compounded by the occurrence of this FAIL event.
- Event DAMAGE An element is damaged by a detonation of an air-to-surface missile. The DAMAGE event is processed in precisely the same way as a FAIL event. The distinction between the two events lies not in how they are processed but rather in that whereas FAIL represents the consequences of a random fault, DAMAGE is the effect of an IMPACT event.
- Event DOWN An element becomes inoperable as a result of a
 DAMAGE or FAIL event. If possible, a repair cycle is scheduled
 to be initiated at a future time. A DOWN event may still occur
 for an element already in a down state as a consequence of an
 earlier DOWN event, in which case the scheduling of repairs may
 be affected.
- Event UP The repair cycle for a disabled element is completed. However, if the element is awaiting the initiation of additional repairs as a consequence of a new DOWN event, the completion of the current repair cycle does not change the down state of the element to up.

• Event REPAIR - A repair cycle for a disabled element is initiated. If the element was being repaired at the instant prior to the time of the current REPAIR event, a new repair cycle is begun with a compounded repair rate which reflects the multiple disablements.

• Event OFF and

Event ON - The OFF event indicates that an element has become inoperable by setting the on/off state of that element to off. In addition it schedules OFF events for all elements dependent on the given element for thier own operability. Similarly, an ON event indicates that the given element and all elements upon which it depends are now operable. Although OFF (and ON) events are the most elementary of all events in the model, in terms of the game they are of primary importance, for these events determine the available weapon systems which can be employed for fleet defense as a function of time. Thus, the set of on/off states of all elements belonging to all ships yields the state of readiness of the fleet.

3. BLOCK STRUCTURE OF THE SIMULATION MODEL

The SPEARS simulation model consists of two separate computer programs: the Pregame Processor (PGP) and the Main Simulation Processor (MSP). The two programs are linked by Replication Data files written on a magnetic tape. This model structure allows review, modification, and correction of input data as required prior to execution of the game situation, or the programs may be run back-to-back if desired.

As shown in Fig. 3-1, the PGP is made up of a number of "generator" routines, each of which processes a portion of the PGP input card deck as described in Appendix A. The Type Generator and Boolean Function Generator add to or modify the standing data base of recurrent offense and defense system characteristics.

The Defense Generator, Sector Generator, Option Generator, Environment Generator, and Communication Generator combine data from input cards and from the Type Data base to produce individual defense units. In the Defense Generator, the ship type and position coordinates of each unit are defined with cards of Type DF. The Sector Generator allows restriction of surveillance radar search sectors and of launcher fire zones as well as specification of launcher salvo sizes. The simulation model options desired for each surveillance radar and for each guidance channel group (tracking radars) may be specified in the Option Generator. The existence of each ship-to-ship communication link at the outset of the game and the specification of those links subject to disruption are defined by inputs to the Communication Generator. The Environment Generator accepts input specifying wind speed at a given altitude and the nominal reflection coefficient of the ocean surface.

The Raid Generator combines numerous kinds of input cards with the Type Data base to produce individual offense units and their piecewise linear flight paths. Both impacting and nonimpacting target types are described, and the pairings of (impacting type) offense weapons with individual defense units are specified.

Numerous checks for data validity are made throughout the generator routines, and error messages are printed as appropriate. In addition a final overall data-consistency check is made following completion of card inputs to the PGP. A summary of the input data and the resulting defense and offense units is then printed.

Depending on a PGP control card option, the revised Type Data may be written (rewritten) on the first file of the Type/Replication tape. If the input data have been found to be error free, a Replication Data file will also be written as specified on the PGP control card. At this point the game inputs may be reviewed by the responsible analyst.

The MSP combines various input data cards (Appendix A) with the specified Replication Tape file to produce a game situation ready for play. Certain pregame data may be printed if desired, as may the

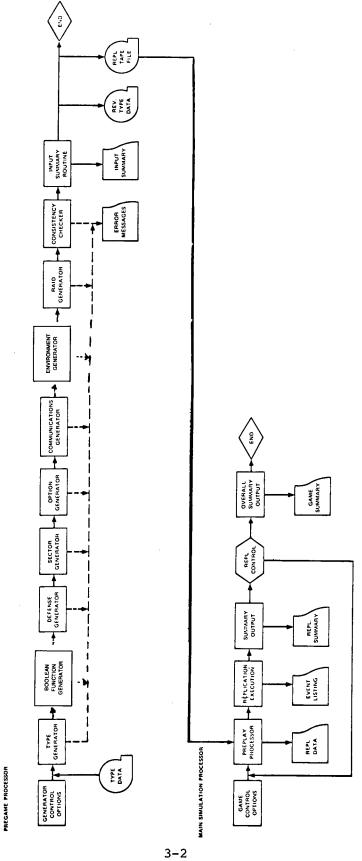


Fig. 3-1 - Block structure of the simulation model

occurrence of selected event types throughout one or more replications. A summary listing is produced at the conclusion of each play of a game situation (after each replication). After the final replication has been made, an overall game summary is produced, similar in format to the individual replication summaries.

Should additional replications of a game situation be desired after review and analysis of the MSP outputs, they may be obtained easily by reuse of the Replication Data file and appropriate modifications to the MSP input card deck (e.g., the replication numbers desired and the random number generator initialization).

4. THE PREGAME PROCESSOR

4.1 Initial Setup of the Model

Two tasks are involved in making initial preparations to use the model. First is the adaptation of both parts of the simulation program, the Pregame Processor (PGP) and Main Simulation Processor (MSP), to the computer to be utilized. This involves choosing the dimensions of various arrays, compiling program subroutines, and producing suitable versions of the two short machine-dependent interface routines in each program. The second task in preparing for production consists of using the PGP to establish a data base of various types of frequently used component and system descriptions. For example, once a SAM missile type has been defined (including its performance envelope, time-of-flight and lethality characteristics), that definition will be saved on a magnetic tape file of Type Data prepared by the PGP from which it may be easily retrieved for use at any later time.

The TEWA functions are not presently operating within the TDHS version of the model, so the storage arrays associated with those functions are assigned minimum dimensions in order to conserve the amount of core space occupied by the simulation program.

4.2 Adaptation to a Particular Computer Installation

The model makes use of a number of packed lists as specified in Appendix B. The virtue of the packed-list format over the whole-word format is that it achieves more-than-an-order-of-magnitude savings in core space requirements for the data it contains. The array dimension to be associated with each such packed list depends on the word length (in bits) of the computer being used. The procedure for dimensioning these arrays for a given machine word length and model capacity is specified in Appendix D. Several types of input and control data include 20-character alphanumeric (name) fields. Successful handling of such name fields requires assigning a value to the parameter N2OBCD in common block 10 (Appendix C); this same numerical value must then also be used as the first dimension of each of the alphanumeric arrays in common block NAMES. Also, certain FORMAT specifications must be changed to correspond with the value assigned to N2OBCD; the nature of these changes is described in Appendix D.

Two machine-dependent routines in both the PGP and the MSP are GETBIT and MOVE. They are required for the storage and retrieval of integer data contained in the various packed lists. Both routines involve masking and shifting operations which should be accommodated readily on any computer. The GETBIT routine has an entry point (which is not USA Standard) called PUTBIT. Most FORTRAN compilers will accept this deviation from the USA Standard easily. If difficulty is encountered, GETBIT may be broken into three separate subroutines—GETBIT, PUTBIT and a new routine which would consist of the majority of the present GETBIT routine.

The most important parameter in GETBIT is IWL, the integer word length (in bits) of the machine being used. Each packed list is considered to be a contiguous string of bits, and the machine word length is of course required to set up addressing pointers within the list. Adaptation of GETBIT/PUTBIT and MOVE to the computer to be used will be easy for a programmer familiar with the chosen computer, requireing no more than a few hours of effort.

Together the PGP and the MSP contain approximately 16,5000 punched cards. However the PGP and the MSP need never occupy core storage simultaneously, as explained in this and the following section. The program decks are heavily annotated with comment cards describing the purpose of each routine, defining the variables used, and explaining significant operations within each routine. Once the array dimensions have been established both the PGP and the MSP should be compiled, and compilation listings (with multiple copies as appropriate) and object code (binary) card decks should be obtained. Virtually any FORTRAN compiler should accept the routines written in USA Standard FORTRAN with few compilation difficulties.*

4.3 Establishing a Data Base

Much of the data needed to define the characteristics of the offense and defense units in a typical AAW engagement are recurrent; once they have been defined, the data may be reused repeatedly in the specification of many similar engagements. To facilitate reuse and revision of such data, the model allows for saving several categories of data on a magnetic tape file from which they may be easily recalled. The Type Generator (TYPGEN) routine within the PGP allows addition to, or revision of, the data base by means of punched card inputs. The two primary categories for which Type Data may be defined are: Ships or Defense Units (including AEW aircraft), and Targets or Offense Units.

4.4 Generation of Ship Types

4.4.1 Ship Description

Specification of a ship type, which may be thought of as a ship class description, requires previous definition of the basic components of which the ship is composed. Specifically required, (Fig. 4.4-1) along with the ship geometry, are the characteristics of the

^{*}An example of a FORTRAN partially incompatable with USA Standard FORTRAN is that provided on the CDC 3800, which will not accept the Standard version of a DATA statement. The authors would appreciate being advised of any such difficulties encountered by users.

surveillance and tracking radar types (e.g., AN/SPS-48, AN/SPS-49), the surface-to-air missile types and their associated launcher systems, and the guidance channel constraint group types. The number and physical location on the hull of each such component, together with individual component vulnerability data, define the surveillance and weapons configuration of a particular ship type; the ship type may also be assigned a class name of up to 20 characters (e.g., DDG-2 CLASS or GALVESTON CLASS). Sub-routines used by TYPGEN to define surface-to-air missile types, launcher types, radar types, ship component types, guidance channel constraint group types, and ship types are MSLGEN, LCHGEN, RDRGEN, CMPGEN, GCGEN, and SHPGEN respectively; the data input formats for each of these routines are given in Appendix A together with amplifying descriptions of the various parameters involved.

The TDHS mode requires the addition of one parameter (on Card Type TS) and a new input card type. The new parameter specifies for a given ship type the number of DET/TRK operator positions available on the ship type. The new card type (Type TST) specifies the radar assignments for the TRK SUP and for each DET/TRK operator. Provision is also made on this card type to assign individual operators to automatic offset mode of operation for the track updating process.

4.4.2 Missile Guidance Techniques

The concept of guidance channel constraint groups (Appendix G) has been introduced into the model so as to afford a single approach to simulating present-day, as well as future, missile guidance techniques. The widely used dual-simplex guidance scheme uses two fully dedicated director-illuminator tracking radar sets (or guidance channels) with each SAM launcher. A quidance channel is entirely committed to a single engagement from initial target acquisition and missile launch to intercept and kill evaluation; thereafter the guidance channel may be used to reengage the same target or to take under fire some other target, as the assignment doctrine dictates. More efficient use is made of the missile launcher by having it supply missiles to two guidance channels conducting independent target assignments; this is particularly true when the missile time of flight to an intercept point is large compared with the launcher cycle (or reload) time delay. A dual-simplex system may have no more than two assignments (per launcher) in progress at any given instant of time.

A somewhat different guidance scheme for more advanced missile systems abandons the notions of fully dedicated guidance channels and exclusive commitment of a guidance channel to a target throughout the course of a missile-and-target engagement. With the advanced guidance techniques a particular guidance channel may be serviced by any of several missile launchers aboard the ship, and it may divide its time among several missile-and-target engagements as the data rate requirements of each dictate. Physically the "guidance channels" in a multifunction phased array radar are more difficult to visualize than the

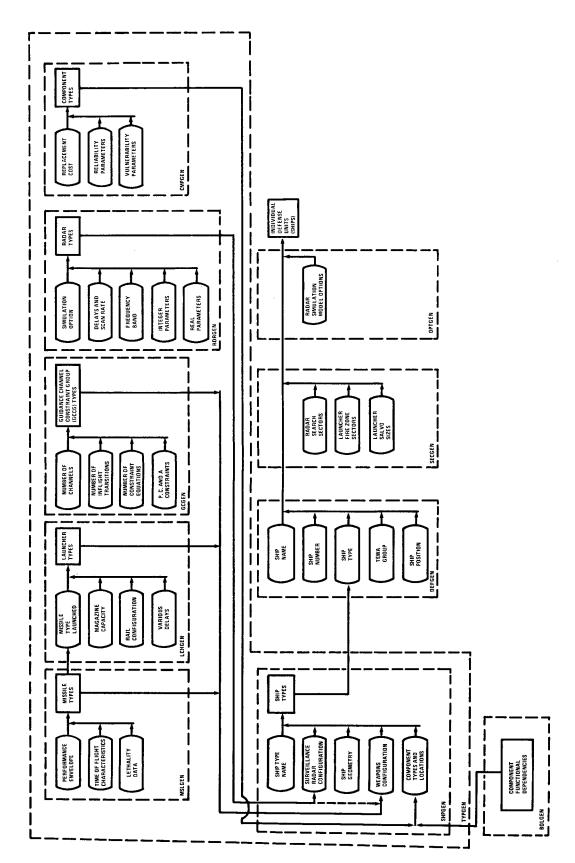


Fig. 4.4-1 - Generation of defense units

director-illuminators of a dual-simplex system. In the advanced system, the energy represented by the fraction of real time devoted to missile tracking and guidance functions may constitute the guidance channels. The allocation of such energy over time as missile-and-target engagements are conducted must observe some physical limitations. In this model the guidance channel constraints are described by a system of linear inequalities, the parameters of which are specified as inputs. Up to seven inflight data-rate changes are allowed, with the data-rate transition points being specified on input as fractions of the expected missile time of flight for each missile-and-target engagement.

One of the parameters required to define a guidance channel constraint group is the total number of guidance channels belonging to the group. For a dual-simplex system this value is two (the number of director-illuminators). For the advanced system the value assigned corresponds to the maximum number of missile-and-target engagements that may be in progress at any given instant of time. The number of channels is a factor on the right-hand side of the linear inequality constraint expression, allowing the constraints to become more restrictive as battle damage reduces the weapon system's ability to direct defensive firepower.

A guidance-channel constraint group may service one or more missile launchers, and these launchers need not be of the same type nor must they launch the same type of missile. The association of a guidance-channel constraint group with its launchers is done in the SHPGEN routine (see Card Types TG, TGP, TGC, TGA, and TSG in Appendix A). A ship type may have up to seven guidance-channel constraint groups but the total number of guidance channels on a ship type may not exceed 63. Thus a double-ended dual-simplex ship having several single-channel point defense systems may be easily accommodated. The approach developed for the model is considered to be sufficiently general and powerful to simulate virtually any shipborne SAM system for the foreseeable future.

4.4.3 Component Functional Dependencies

The operational dependencies of ship components on one another is described within the simulation by means of Boolean functions. A guidance channel for instance might be modeled as being operationally dependent on a fire-control computer and a power supply; that is, if either the fire-control computer or the power supply is not functioning, then the guidance channel is unable to operate. The Boolean relationship expressing this dependency would be of the form

1 AND 2, 3,

where the Boolean function 1 is associated with the guidance channel, the component 2 with the fire control computer, the component number 3 with the power supply, and the logic indicator AND with the fact that the operability of the guidance channel depends on the operability of <u>both</u> the fire control computer <u>and</u> the power supply. The fire-control computer in turn could depend operationally on one or more ship components, so that any desired dependency configuration can be constructed.

A master set of Boolean functions is inputed for each game replication (see card type BF in Appendix A). Each ship component is assigned a Boolean function number from the master set as the component is defined within ship type; the absence of such an assignment indicates the ship component is operationally independent of all other aboard ship.

4.5 Generation of Target Types

Impacting and nonimpacting target types and ECM loading groups are specified within the TYPGEN routine as shown in Fig. f.5-l. Radar reflection data is referenced by cross-section group numbers and may be shared by several target types as appropriate. Cross-section data are processed by the CSGEN subroutine. Within the TGTGEN routine each target type is assigned a data-base reference number and a 20-character name (e.g., BADGER D, SSN-3, SUBMARINE). The vulnerability group index of a target type is used to select the applicable set of kill probability values for a SAM system whenever a missile-and-target intercept is achieved by the defense forces; thus one set of \mathbf{P}_k values might be specified for aircraft targets and a second set for cruise missiles for each SAM type.

For launch vehicles and impacting target types the dispersion characteristics are defined by TGTGEN inputs. These may be in the form of either DEP/REP (deflection error probable/range error probable) or CEP (circular error probable). For launch vehicles the dispersion data are used to establish an aim point for its weapons, centered about the position of the intended victim ship. The dispersion of impacting weapons is centered about the airm point so defined. By setting both of these dispersion characteristics to zero, an enemy weapon may be made to impact at exactly the position of the victim ship. The extent and nature of damage caused to shipborne components by an enemy weapon impact is derived from the distance separation between the warhead and each component, the warhead size or lethality figure, and the vulnerability factor of each component (as specified in the SHIPGEN inputs).

Four of the TGTGEN inputs are applicable only to impacting target types. The guidance-dependency parameter specifies whether the flight of an impacting target type should be aborted whenever its parent launch vehicle is killed (if this should occur in the time interval between launch and impact of the target). The speed standard-deviation value is used to allow random differences in the actual speeds achieved by individual impacting targets. A "slow" missile will have speed values less than the nominal mean-value figures (inputed later in the WPNGEN routine) along each of its flight path legs. This increases

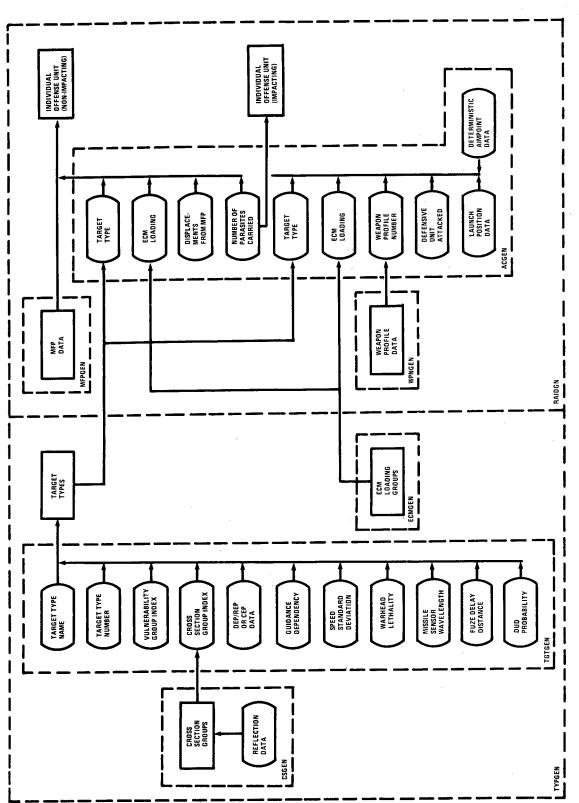


Fig. 4.5-1 - Generation of offense units

the variability of enemy weapon impacts and imitates a factor not strictly under control of the enemy raid planner.

Enemy missile fuzing occurs at the point of impact of the missile with whichever is contacted first, the ocean surface or the target ship. The position of detonation is located generally beyond the fuzing location on the path of motion of the enemy missile. The distance from the point of fuzing to the point of detonation is a TGTGEN input.

The probability that the enemy missile will fail to detonate is used to determine (through the choice of a random number) whether that missile is a dud.

Finally, the jamming power densities on P, L, S, C and X bands may be specified by inputs to the ECMGEN routine. These ECM loading groups are then accessed (by group index number) within the Raid Generator to establish the jamming configuration of individual enemy vehicles. Both impacting and nonimpacting target types are permitted to carry any combination of ECM equipment specified by the analyst laying out the raid configuration.

4.6 Retention of Data Base Parameters

The use of previously defined Type Data and the retention of newly defined Type Data are entirely under the control of the analyst preparing inputs for a particular run (specifically Card Type C in Appendix A). The intended purpose of the data base (and the Type Data magnetic tape file) is to permit a "one-time" definition of frequently used information, particularly in the case of ship and target types. Once such definitions have been accomplished, later runs may be made with significantly smaller input card decks.

Any set of Type Data may be newly defined or redefined for an individual run, and these definitions may be temporary (no change made in the previously written magnetic tape file) or permanent (by rewriting the tape file). The user must exercise caution in redefining an existing Type Data set, since any other set of Type Data affected by the change must also be redefined. For example, if the number of channels within a guidance channel constraint group type were to be changed, this would necessitate redefinition of any ship types utilizing that guidance channel constraint group type; in particular the tracking radars and component characteristics associated with guidance channels for the ship type would require modification. On the other hand some changes may be made in Type Data sets without requiring subsequent redefinition of "using" data sets. For example the location of a performance-envelope node of a missile type may be moved or a new node may be added without necessitating redefinition of every ship type using the affected missile Recognizing the conditions under which such a change is permissible requires intimate knowledge of the PGP structure. When in doubt, the safest alternative is of course to redefine any other Type Data sets that might possibly be affected.

4.7 Specification of Defense Units

Once a library of ship types has been established in the data base, specification of individual defense units (ships and AEW aircraft) is relatively easy. Each defense unit must be defined by a single input card (of Type DF) to the Defense Generator (DEFGEN) routine. Each such DF card specifies the number, name, ship type, heading, and position (in rectangular or cylindrical coordinates) of a defense unit. Also specified is a TEWA group number for defense units having firepower capabilities; this grouping is used within the threat-evaluation procedure in the determination of the force-wide engagement status of individual targets. Inputs to the DEFGEN routine are terminated by a Type DX card; this card is also used to specify the location of the Vital Area Center used in force-wide threat-evaluation computations.

Following the DEFGEN inputs there may be additional, optional inputs to further refine the descriptions of individual defense units. These optional inputs fall into three categories; surveillance-radar search-sector definitions, launcher fire-zone sector and salvo size definitions, and radar simulation-model option selections for individual surveillance radars and guidance channel groups.

Any, all, or none of the surveillance radars aboard a defense unit (as determined by the corresponding ship type definition) may be assigned limited search sectors by use of input cards of Type SR to the Sector Generator (SECGEN) routine. Unless otherwise specified, all surveillance radars are allowed full circle coverage. Restricted search sectors are defined by giving a right-hand boundary (relative to the ship's heading or to north, as desired), and a search sector width (of from 0 to 360 degrees). Each radar is then prohibited from making target detections outside of its assigned search sector. (Individual surveillance radars may be "turned off" simply by assigning a zero-width search sector; this is an easier way to remove a radar from a ship than by going through the alternative approach of defining a different ship type.)

Fire-zone sectors for individual missiles may be defined in a similar fashion through the use of Card Type SL. Full circle coverage is again assumed unless otherwise specified. Each launcher is prohibited from launching a missile salvo against a target unless the target lies within its fire-zone sector at the time the missile assignment is made. This same card type is also used to specify the salvo size for individual launchers (the number of missiles to be fired each time as an assignment is made). A default value of one (single missile salvos) is assumed unless otherwise specified.

Only one such unit may at present be configured with surveillance radar sets in the TDHS version. Until the development of the multiple-ship TDHS model, all defense units but one must be generated from ship types having no radars or defensive weapon systems.

Several radar simulation models are available within the program, each representing a different level of detail or degree of sophistication in the treatment of the radar detection process. Which radar simulation option(s) to use in a particular run depends on many factors, including the purpose of the run, the sensitivity of the outcome expected or previously observed as a result of the option(s) selected, and the importance attached to minimizing computer running-time costs(through the selection of simple algorithms). Each surveillance radar and each guidance channel group (tracking radar(s)) may be independently assigned the simulation model option desired. Thus a number of different radar simulation models may be employed concurrently within a given run. less otherwise specified, the simplest radar model is assumed (a deterministic cookie-cutter technique); this will yield the shortest possible running time, but only radar horizon, scope limit, and horizontal and vertical coverage angles will be considered in making detection decisions--effects of ECM and target cross section variations are ignored.

In the TDHS version the radar simulation algorithms no longer produce "detected" targets but rather yield an array of detectable video coordinates. A clustering routine in the MSP adjoins the video returns from closely spaced targets according to the radar resolution capabilities and other TDHS tracking parameters.

4.8 Specification of Offense Units

The Raid Generator (RAIDGEN) routine combines previously defined target types, ECM loading groups, and defense unit information (for targeting purposes) with flight-path and weapon-trajectory data to produce individual offense units, both impacting and nonimpacting, as diagramed in Fig. 4.5-1.

Every offense unit, or target, is associated with a piecewise linear Master Flight Path (MFP). The MFP for a nonimpacting target (e.g., launch vehicle, standoff jammer, strike-command aircraft, or cruise-missile-launching submarine) may have from two to 15 nodes (X, Y, Z). The phasing or time of departure from the first node and the speed along each flight path leg are MFP input parameters. Offense units flying in formation may be associated with a common MFP, with the lateral, axial, and vertical displacements of each from the MFP being described with the specifications of each such target. (The MFP for a nonimpacting target must be completely described as part of the run input data, and there is no variation in such flight paths between successive replications.)

Any number of nonimpacting targets may share the same basic MFP, with each such target being described by a single input card of Type RA. This card specifies the target type and ECM loading group (both previously defined by inputs to the TYPGEN routine), the displacement values (relative to the most recently defined MFP), and the number of parasites carried (if any).

Each parasite carried by a launch vehicle is defined by a single input card of Type RAP; the RAP card(s) must immediately follow the RA card of the parent launch vehicle. The parasite-description card specifies the target type and ECM loading group (just as for nonimpacting targets), the weapon profile number applicable to the parasite (discussed in the next paragraph), the defense unit to be attacked by the parasite, data necessary to define the time interval during which the parasite may be launched from its parent vehicle (according to a uniform probability distribution over the interval), and a deterministic aim point, if applicable.

The MFP's for impacting targets are generated somewhat differently than for nonimpacting targets. Since the exact launch time of a parasite is allowed to fall randomly within a specified interval, and since the impact point is determined randomly (based on the weapon dispersion characteristics), each impacting target is given a unique MFP at the time of its launch. These MFP's will in general be different from one replication to the next. The data from which such an MFP is derived are termed the Weapon Profile Data and are initially processed by the WPNGEN routine. The speeds, altitudes, climb and dive angles, and ranges are described as appropriate to the type of weapon profile. Three profiles are presently defined, having one, three, and four flight-path legs respectively (Card Type RW in Appendix A).

A nonimpacting target may act as the launch vehicle for from zero to 15 parasites. There may be up to 255 targets generated by the inputs to a particular run.

There are two minor changes in specification of offense units for the TDHS version. The first of these relates to the defense unit against which an impacting target is assigned. A new data field has been added in order to identify the intended victim, which may in general differ from the actual victim against which the target will achieve impact if it survives long enough. The intended victim identification is carried along strictly for information and subsequent summary-listing tabular printout. It has no effect on execution of the simulation model but can be used to facilitate comparison of raid conditions with predescribed scenarios.

The second change allows the probabilities of prelaunch, inflight, and detonation failure to be specified for each impacting target. Application of these probabilities will be discussed in the MSP section.

4.9 Preparation of Game Inputs

The ship types, target types, and ECM loading groups to be used in a particular play of the game must either have been already defined in the data base as discussed previously (and have been written on the magnetic tape Type Data file), or those new or redefined sets of Type Data must be included in the PGP input card deck being prepared. Newly

defined Type Data may or may not be saved on the magnetic tape depending on the control options selected on Card Type C (Appendix A). The TYPGEN trailer card (Card Type TS) signals the end of the inputs intended to modify the data base. Following the TYPGEN trailer card in the PGP input deck are the Defense Generator (section 4.7) and the Raid Generator (section 4.8). The structure of the PGP input deck is discussed in detail in Appendix A.

There are countless ways in which errors may creep into preparation of an input card deck for a large-scale model such as this. The PGP is designed to recognize the occurrence of many types of such errors and take (temporary) corrective action whenever appropriate. An informative diagnostic message is printed on the output listing of the PGP (as specified in Appendix E) as faults are encountered in the input data. There are two main categories of errors (and error messages): fatal and nonfatal.

Fatal errors are those from which the PGP is unable to recover in any meaningful way so as to proceed with processing the input deck. Whenever a fatal error is encountered, an error message will be printed, the input process will be terminated, and an input summary listing will be printed with all of the data as they had been defined up to the occurrence of the fatal error.

Nonfatal errors are those from which the PGP can recover, at least temporarily if not entirely correctly. Whenever a nonfatal error is encountered in the definition of a data set, default values may be assigned in lieu of incorrect ones, or entire sets of data may be ignored by the PGP as appropriate to the particular type of error. In addition, the affected data set will be tagged as being "bad." Any other dependent data set will in turn be termed "not well defined." For example a ship type would be not well defined if its configuration included a missile type that had included an error in its definition.

The philosophy applied to the PGP design has been to process as much of the input deck as possible on a single pass, taking corrective action wherever feasible and printing error diagnostics as appropriate. In this manner fewer passes through the PGP should be required to correct a faulty input deck.

4.10 Pregame Processor Outputs

Essentially five kinds of output may be produced by the Pregame Processor: a pseudo 80-80 listing of input card images, a recapitulation of all or a portion of the Type Data available to the TYPGEN routine, a complete description of the defense and offense forces that have been defined, a magnetic tape file of Type Data that may be reused for later simulation runs, and a magnetic tape file of Replication Data to be used by the Main Simulation Processor as the scenario for an actual simulation run.

The listing of input-card images may be useful as a record, as a check on the keypunching, and as a convenient form for review and revision of the input deck. This listing is not strictly an 80-80 card image listing, since the same format is used to pring the card image as was used to read it. For example floating-point values will always be printed with three digits to the right of the decimal point regardless of the format actually used on the input card. Similarly an integer value intended to be a 4 but mispunched into column 59 (rather than column 60) would be printed out as a 40 (which would in fact be the value understood by the program to be the one desired). The listing of input-card images is entirely optional and may be suppressed by placing a 0 (or a blank) in column 50 of the PGP control card.

The Type Data listing may include either all such data available to the TYPGEN routine (including that obtained from magnetic tape if applicable) or only that data newly defined by card inputs to the TYPGEN routine. The layout of the Type Data on the printer page has been carefully designed to enhance its usefulness and readability. Each category of Type Data (e.g., missile types, radar types) is started at the top of a printer page to achieve visual separation between groups of dissimilar data. Only the listing of previously defined Type Data may be suppressed by an input control option.

The composition of the defense and offense forces will always be printed out in its entirety. The formats used are somewhat condensed in that for a full and complete understanding of each offense or defense unit, one must also have access to the Type Data printout. Defense units are listed in numerical order, although they need not be generated in this order. Weapon profile descriptions are printed by themselves, since they may be used from within any portion of the raid structure. Each MFP that has been defined will be listed at the top of a printer page, followed immediately by descriptions of all targets using that MFP, together with the parasites (if any) of those targets.

A sample PGP input deck and the resulting summary listings are presented in Appendix H. No particular importance should be attached to the numerical values given in the sample input deck since many values are fictitious so as to keep the material unclassified.

The Type Data magnetic tape file may or may not be written (rewritten) after the summary listings have been produced, depending on whether any new sets of Type Data are or are not intended to become a "permanent" part of the simulation model data base. As the model is presently structured, only one magnetic tape is used for both the Type Data and Replication Data files. The Type Data file is always the first file on the tape and it must have been written at least on time in order for the Replication Data file to be successfully written. Therefore a Replication Data file cannot be written on a new tape without a Type Data file having been previously written. Prior to writing either kind of tape file, all data are tagged as being "old" so as to differentiate then from newly defined (card input) data on later runs.

The Replication Data file describes a complete game situation for the Main Simulation Processor by passing along various arrays, packed lists, and control parameters. Provided that the Type Data file is not rewritten, several Replication Data files may be placed on the same magnetic tape. The number of previous Replication Data files to be saved is specified on the PGP control card. (It should not be assumed that a Replication Data file sandwiched between others can be rewritten in place without destroying those files which follow it; a much safer procedure would be to abandon such a file and create a new Replication Data file after the last file to be retained.)

5. THE MAIN SIMULATION PROCESSOR

5.1 General

Adaptation of the Main Simulation Processor (MSP) to a particular computer installation is similar to the procedure described for the Pregame Processor. Nearly all of the packed list and name array dimensions will have been previously established for compiliation and execution of the PGP; it is merely required that these same dimension values be used in the corresponding common blocks within the MSP. Those few lists and arrays unique to the MSP must be assigned appropriate dimensions, following the procedure given in Appendix D.

The MSP is loaded into the computer as a separate program, thus minimizing the amount of computer core space required for execution of the model; that is, the PGP and the MSP need never occupy core space simultaneously. The magnetic-tape Replication Data file(s) provides the necessary link between the PGP and MSP computer programs.

The MSP requires an input deck of from two to 20 or more cards, as described in Appendix I. The first card specifies the selection of several input, and replication control options, together with a 20-character run identifier. The second card is used to specify several delay time values, a maximum simulation time, and an event monitoring time interval. The next card, when it is included in the input deck, defines a subset of the event types which is of interest for detailed printer listing as specified on the first two input cards. The remaining cards, when included, cause controlled initialization of the random-number generator. Five additional input card types are used only in the TDHS version of the model, as discussed below.

After the MSP input card deck has been processed and the specified replication tape file has been read into the machine, a prereplication initialization routine makes the final preparations for a play of the game. Several events will have been prescheduled in the game event-store calendar by the Pregame Processor; these include the first NODE event for each nonimpacting target in the offense force, and it is the earliest of these that actually gets the game underway.

The currently defined event types (Appendix J) fall into four broad categories: target-motion events, radar-detection/tracking events, threat-evaluation and weapon-assignment events, and kill, damage, and disablement events. The types of events in each of these categories are discussed in the remainder of this section.

Changes made in the Main Simulation Processor (MSP) in the TDHS version of the model include additional of several new game-control and override-option data cards, addition of several new event types, and suppression of several old event types. The relationship between the PGP and the MSP is the same as in the parent model except that the arrays and their dimensions on the replication tape file are somewhat different.

Five new types of game control cards are now read in after the random-number-generator initialization cards. As described in Appendix I, these control cards specify various details about the target tracking process for a particular play of the game. The tracking parameters include specification of the size and shape of the reachable sets used to compute video-track correlation scores, the rules by which DET/TRK operators are activated (or deactivated) depending on the total number of tracks in the TDHS, the rules by which closely spaced multiple video returns are tracked together or separately, and the zone of interest boundaries within which a DET/TRK operator's attention is directed during automatic sequencing.

Three of the five new card types are used to override equipment accuracy and operator proficiency values. Included in the parameters that may be so modified are ball tab placement errors, scope limit scale factors, and service time limits (minimum and maximum values) for individual operators and range and azimuth accuracy for individual radars.

5.2 Target Motion Events

There are four event types primarily related to target motion: NODE, VANISH, IMPACT, and EMERGE. A NODE event occurs whenever a target (offense unit) passes through one of the nodes along its piecewise linear flight path, including departure from the initial node and arrival at the terminal node. Associated with the NODE event is one of the most complex subroutines in the model.

The occurence of a NODE event will always result in the scheduling either of a simultaneous VANISH or IMPACT event as appropriate or of another NODE event for the time at which the target reaches the end of its current leg. Additional events related to radars (ENTER, LEAVE), weapons (DROP, TRNSFT, ABORT, COMEIN, OUTGO), and parasited (EMERGE) may also be scheduled if and when appropriate.

Consideration of the NODE event may be divided into two general cases: (1) when the occurrence of a NODE event corresponds to the final or terminal node of the target's flight path, and (2) all other NODE event occurences (those for which one or more additional flight-path nodes remain for the target to pass through). Of these the first case is the simplest, since all that is done is to schedule either an IMPACT or a VANISH event at the current game time, depending on whether the target is of an impacting or nonimpacting type.

⁽Card Types GTP, GSF, GBT, GRE, and GST.)

For the second case the NODE-event subroutine must take a number of actions related to radars, to SAM weapons, and possibly to launch of parasite targets. The term "current leg" is applied to the line segment from the current node (the one being processed) to the next flight path . The times at which the current leg penetrates the coverage volume of each radar set in the defense force are computed, and ENTER and/or LEAVE events are scheduled accordingly. Each currently held assignment of a SAM weapon to the target being processed must be examined to determine if the target course change does or does not allow the assignment Depending on the outcome of a series of tests, the time to continue. schedule for such an assignment may be adjusted to a new predicted intercept point, or the assignment may be terminated or modified through scheduling of a DROP, TRNSFR, or ABORT event as appropriate. A time interval is determined with respect to each defense unit during which new SAM-weapon assignments may be made. If the target does not come within assignment range of a particular defense unit during the current flight path leg, or if the defense unit has no SAM weapons, then the intervel will be of zero width. Otherwise a COMEIN/OUTGO event pair will be scheduled for the defense unit/target combination at the times corresponding to the beginning and ending of the assignment time interval; it is permissible for this time interval to include the entire current leg, resulting in the COMEIN/OUTGO events being scheduled concurrently with the initial and terminal nodes respectively of the current flightpath leg. If launch of one or more parasites is keyed to the flightpath node being processed (for a launch platform or weapon carrier), the exact launch and impact points are determined, and an EMERGE event is scheduled for each such parasite.

Occurrence of an IMPACT event causes assessment of damage to components on the targeted defense unit. Damage probabilities are calculated from an estimate of the severity of the blast, which is derived from the warhead size of the impacting target, the relative vulnerability of each ship-based component, the distance of each such component from the detonation point of the impacting weapon, and the nature of the medium between the two. Monte Carlo evaluations are made for disablement of individual components, and DISRDR, DISCHN, and DISLAN events are scheduled for the disablement of radar, guidance channel, and launcher systems as appropriate. The (impacting) target is then removed from the play of the game, and any radar-detection or weapon-assignment events affected are suitably modified or canceled. Processing of a VANISH event (the final node of a nonimpacting target) is similar to the IMPACT event except for the damage-assessment portion, which of course does not apply.

The coverage volume of a surveillance radar set is determined by the radar horizon constraint, maximum unambiguous range (scope limit), horizontal search sector limits, and vertical search sector limits.

An EMERGE event corresponds to the launch of a parasite (impacting target type) from its launch platform. This event simply schedules the first NODE event for the parasite, which thereafter becomes an active offense unit in its own right.

In the TDHS version of the model, if it is determined during game play that a prelaunch failure has occurred, then a PRELF event will be scheduled at the game time which would have otherwise corresponded to the EMERGE event for the missile. When a PRELF event occurs, the affected cruise missile is simply removed from further consideration. Subsequent launch times of other missiles from the same launch platform are unaffected by the occurrence of a prelaunch failure.

Whenever it is determined that a cruise missile is going to suffer an in-flight failure, the time of failure is assumed to fall anywhere along its flight path with equal likelihood (uniformly distributed over the time interval between the EMERGE and IMPACT events for that missile). An IFFAL event will be scheduled at the selected time, and its occurrence will be processed in much the same way as a VANISH event.

5.3 Radar Detection Events

There are seven event types primarily related to detection of offense units by the surveillance radar network of the defense force: SCAN, DETECT, PASS, PSSDET, LOSE, ENTER, and LEAVE. Associated with each surveillance radar set is a periodic scan rate equal to the time required for the radar to make one sweep through its coverage volume. For radars with mechanically rotating antennas the scan rate is the amount of time required for one complete revolution of the antenna. Once per scan period each radar set attempts to detect any live active targets not already held in a detected status with respect to the radar; this action corresponds to an occurrence of the SCAN event. The radar-simulation model employed for this purpose depends on the option selection specified for the radar set as part of the PGP inputs.

If it is determined within a SCAN event that one or more targets become detected by a particular radar, then a DETECT event is scheduled for each such radar-and-target combination at the same time as the SCAN event (at present game time). Occurrence of a DETECT event causes the target to be indicated as being in a primary detection status with respect to the radar making the detection and in a secondary detection status with respect to all other radar sets aboard the same defense unit. A secondary detection is simply the knowledge of a target's position by virture of communication from another radar set able to see the target (from a radar set holding the target in a primary detection status). The DETECT event will also schedule a PASS event at a time corresponding to current game time plus a communications time delay.

When a PASS event occurs, those defense units able to receive communication transmissions from the defense unit responsible for the

(primary) detection of a target are identified. If any of the individual radar sets on any of these defense units do not hold the target in a detected status (either primary or secondary), then a PSSDET event for each such radar set will be scheduled at the current game time. When a PSSDET event occurs, the specified target is indicated as being held in a secondary detection status with respect to the designated radar set.

The LOSE event corresponds to loss of a primary target detection by a particular radar set due to the target's passing outside the coverage volume of the radar, the detection radar's becoming disabled through the effects of an enemy weapon impact, or the target detection's probability becoming unacceptably low, as when the target enters a fade zone with respect to the tadar. Occurrence of a LOSE event initiates cancellation of the corresponding primary radar-target detection status and cancellation of any secondary detections found to depend on the existence of the just-canceled primary detection. This may cause reactivation of other radar sets as explained below.

To conserve computer running time, radar SCAN events are allowed to be scheduled only when there are one or more live active targets not held in a detected status with respect to a particular radar and when at least one such target is within the coverage volume of the radar set. The ENTER and LEAVE events, scheduled by the target-NODE-event subroutine, define the time interval(s) during which each target is within the coverage volume of each radar set.

A radar set is said to be "activated" whenever there is a SCAN event scheduled for it in the game-event calendar. Initially no radars are activated, and an ENTER event must occur for activation to take place. If an ENTER event occurs for a target not held in a detected status (primary or secondary) by a nonactivated radar, then the radar will be activated, and a SCAN event will be scheduled for it at a time displaced from current time by a random fraction of the radar's scan rate. Thereafter the SCAN event for that radar will regenerate itself at regular intervals (so that the time between successive SCAN events for the radar is equal to its scan rate). Whenever all live active targets within the radar's coverage volume have become detected, the SCAN event will not regenerate itself, and the radar will become deactivated until an ENTER or LOSE event causes reactivation.

Occurrence of a LEAVE event corresponds to a target's passing outside of the coverage volume of a particular radar set. If the target is held in a primary detection status with respect to that radar, then a LOSE event is scheduled at the current game time, to be processed as described above.

Of the previously discussed seven event types related to detection of offense units by the surveillance radars of the defense force, only two (ENTER and LEAVE) remain active in the TDHS version of the model. In addition the following eleven new event types have been defined for

the detection and tracking process within the TDHS: TRKSUP, TRACKR, NEWDET, SPLITK, LATEDT, LATESP, UPDATE, MISSTK, DROPTK, WAKEUP, and SLEEP.

The track supervisor is said to be activated whenever there is a TRKSUP event scheduled for him in the game-event calendar. Initially no TDHS operators are activated, and an ENTER event must occur for the first activation to take place. As before, the ENTER and LEAVE events, scheduled by the target NODE event subroutine, define the time interval(s) during which each target is within the coverage volume of each radar set. When the first target enters the coverage volume of the radar to which the track supervisor is assigned, a TRKSUP event will be scheduled at a time displaced from the entry time by a random fraction of the radar's scan period. Thereafter the TRKSUP event will regenerate itself at irregular intervals (depending on the task being performed by the track supervisor and the associated service time).

Whenever the first TRKSUP event occurs, the appropriate radar simulation routine is called to produce an array of video data representing the position coordinates (including radar errors and centroid effects) of detectable targets. The track supervisor will then proceed to establish a new track within the TDHS for each such video return, taking a suitably selected length of serving time between each successive track establishment to represent the amount of time required for him to make the necessary console-button-pushing operations.

As the first track is established (and for each multiple of a selected threshold value) a DET/TRK operator is activated through the device of a WAKEUP event. The WAKEUP event is displaced from the track establishment which triggered it by a delay time representing the time required to get an operator alerted from an idle status. Initially no DET/TRK operators are activated and a WAKEUP event must occur for activation to take place. A DET/TRK operator is said to be activated whenever there is a TRACKR event scheduled for him in the game-event calendar.

A new detection (NEWDET) event or a late detect (LATEDT) event for close-in targets signifies establishment of a new air track within the TDHS. Similarly, when multiple video correlate with a given track, a split-track (SPLITK) or late-split (LATESP) event is scheduled.

When a TRACKR event occurs, the primary and secondary zones of interest are computed relative to the current pointing direction of the radar to which the operator has been assigned. If a track eligible for automatic sequencing is available within the zone of interest, the TRACKR event causes the radar video and track symbology to be updated as appropriate. Thereupon a correlation process, based on the reachable set concept, is used to assign video returns to corresponding track symbology.

The video assigned to the sequenced track (the track to which the DET/TRK operator's attention has been directed) will then be used to enter a new position report (including operator ball tab error) by

virtue of scheduling an UPDATE event in the game calendar. The TRACKR event would thereupon reschedule itself, after a suitable delay-time interval representing the period during which the DET/TRK operator is occupied making the necessary console-button-pushing operations.

Should no video correlate with the sequenced track, then a missed-report event (MISSTK) is scheduled for the track and the TRACKR event reschedules itself after the time required for the radar to sweep through the entire width of the operator's zone of interest.

After a predetermined number of successive missed-track reports, a given track becomes eligible to be dropped from the TDHS by the track supervisor. On a time available basis (e.g., when there are no additional new detections to be entered) the track supervisor will schedule a drop-track event (DROPTK) for a track which no longer has correlating video available.

As the workload is lessened in the TDHS (by virtue of a succession of drop-track actions), it may be appropriate to deactivate one or more of the DET/TRK operators. This is accomplished by application of a decision threshold and, when appropriate, scheduling a SLEEP event for an operator; this will have the effect of removing the operator's next scheduled TRACKER event from the game calendar.

5.4 Threat-Evaluation and Weapon-Assignment Events

There are ten event types primarily associated with threat evaluation and weapon assignment: TEWA, ASSIGN, LAUNCH, INTCPT, RELEAS, TRNSFR, ABORT, DROP, COMEIN, and OUTGO. The TEWA (threat evaluation and weapon assignment) event involves several large subroutines and like event type NODE is one of the most complex event types in the simulation model. A TEWA event sequence is associated with each defense unit having SAM firepower capability. Scheduling of the initial TEWA event for a defense unit is triggered by the first detection made with respect to that defense unit; this TEWA event is displaced in time from its generating DETECT event by an evaluation reaction time, the value of which is specified on the GP input data card. Thereafter the TEWA event for the defense unit regenerates itself according to a time interval either as specified on the GP input data card or as determined by the next earliest time of weapon availability.

The total number of targets within SAM assignment range of any given ship is kept by incrementing a counter by one each time a COMEIN event for a particular ship occurs (and by decrementing the counter by one each time an OUTGO event for it occurs). Whenever the in-range target counter for a particular defense unit is incremented from 0 to 1, a TEWA event is scheduled for that ship unless there is already one in the game-event calendar.

When a TEWA event occurs, the value held in the in-range target counter for that defense unit is tested. If the value is 0, control

will be returned immediately to the main program without scheduling a future TEWA event for the ship. Otherwise a preliminary check is made to determine if the specifed defense unit has any weapons available for possible assignment during the current TEWA interval (between current game time and the latest time at which the next TEWA event for this defense unit will occur). If no weapons are available, due to engagements in process and/or to disablement of necessary weapon system components, the event will proceed no further but will simply reschedule itself for the earliest time at which a weapon will become available.

If one or more weapon systems are found to be available on the defense unit, then the TEWA routine will produce a threat-ordered list of the targets currently held in a detected status with respect to the defense unit using a threat-ordering algorithm patterned after the procedure used within the Naval Tactical Data System (NTDS). Threat ordering is done with respect to both own ship and the task force Vital Area Center. Preference is given to self-defense, and then to area defense, with threat-number ties being broken by random-number selection.

Offense units found to have sufficiently high threat numbers are then considered for possible engagement by SAM weapons. The weapon assignment routine verifies availability of the necessary weapon-system components, performs a trial intercept calculation, determines if the predicted intercept point lies within the performance envelope of the missile type being considered, and checks the guidance channel constraint expressions to insure that they are satisfied throughout the expected duration of the assignment. If more than one SAM system aboard the defense unit is capable of engaging the designated target, preference will be given in the following order:

- 1. To the system having the higher priority missile type, where missile priority is inversely related to maximum range capability (reflecting missile replacement costs),
- To the system able to achieve the earliest assignment time within the current TEWA interval, and finally,
- 3. To the system having the greatest number of missiles remaining in its launcher magazine.

Once a SAM system has been selected for the assignment, and ASSIGN event will be scheduled in the game calendar, and if weapons are still available on the defense unit, another target will be considered for possible engagement. This process will continue until there are no more engageable targets or no more weapons available on the defense unit.

The ASSIGN event indicates the pairing of a weapon and a target as determined in the TEWA process. The corresponding LAUNCH event is then scheduled for a time displaced from the ASSIGN time by the target acquisition delay of the guidance system and the firing circuit activation delay of the selected missile launcher.

Occurrence of a LAUNCH event corresponds to the firing of a SAM from its launcher. The computer time of flight to the predicted intercept point is then used to schedule the subsequent INTCPT event.

When the INTCPT event occurs, a Monte Carlo evaluation is made to determine if the missile succeeded in inflicting lethal damage to its assigned target. If so, a second random sampling is made to establish the time required for the target to die (to become ineffective and eligible for removal from the play of the game) and a DIE event for the target is scheduled accordingly. If the time of death so computed is earlier than any previously held time of death for that target, then the later DIE event is removed from the game calendar. At this point the SAM system is tentatively given credit for killing the target.

The INTCPT event also causes scheduling of a RELEAS event for the SAM system at a later time, following the kill-evaluation delay period associated with the weapon type used. Occurrence of the RELEAS event simply releases the weapon system from its most recent engagement, making it available for a new assignment.

However not all SAM engagements can be expected to go smoothly from the ASSIGN to the RELEAS event. Some of the possible causes for disruption of the normal sequence of events in the history of a SAM engagement are:

- The target may change its course in such a manner that interception by the assigned missile is no longer posssible due either to performance-envelope restrictions or to violation of the guidance-channel-constraint expressions;
- The target may be killed by another missile system (target preemption);
- The target may cease to exist, by reaching its final flightpath node (this will normally only happen for impacting target types);
- One or more necessary components of the SAM system may be disabled due to the effects of an enemy weapon impact.

Depending on the nature of the disruption, the time at which it occurs (relative to the predicted SAM engagement history), and the availability of other nearby (indistinguishable) targets, the SAM engagement may be dropped, transferred, aborted, or simply released.

A DROP event will be scheduled if the assignment cannot be completed and if the missile (salvo) has not been irrevocably committed to the engagement. Thus, if the launcher firing circuit has not yet been activated, the assignment will be scratched with no missile expenditure.

If the SAM engagement in question has already achieved its intercept, then the disruption will have little effect on that assignment except that the weapon system release may be scheduled for a slightly earlier time.

A TRNSFR event will be scheduled if the launcher has been fired (but target interception has not yet occurred), and there is available another target to which the assignment may be transferred. The rules by which eligibility for transfer is decided are under control of the programmer so they may be made prohibitive (no transfers allowed), restrictive (transfer allowed to another target occupying the same radar resolution cell as the original target), or permissive (according to virtually any other criteria desired). After a TRNSFR event the remaining engagement events (e.g., INTCPT, RELEAS) will proceed as if the assignment had been originally made to the new target except that they may be rescheduled to reflect a different intercept time.

If the missile has been irrevocably committed to the engagement and transfer to another target is not possible (or allowed), then an ABORT event will be scheduled which will terminate the engagement with the unproductive expenditure of the missile salvo.

This area of the simulation model is currently deactivated in the TDHS version. To bring the TEWA functions into the TDHS SPEARS, it will be necessary to key those functions to track-history data rather than to actual target-position data as is done in the parent model.

5.5 Attrition of Offense Events

There are two event types primarily related to kill, damage, and disablement of offense units: DIE and VICTIM. Both event types relate to the attrition of offense units through the effects of defensive missile firepower and result from the occurrence of an INTCPT event.

Scheduling of a DIE event for a target results from one or more successful intercepts by defensive missile firepower, as previously discussed. If the target has reached its final flight-path node (with a VANISH or IMPACT event) prior to occurrence of the DIE event, then no further action is taken since the target would have been already removed from the game play. Otherwise the target is tagged as being "dead" and the SAM system reponsible for the DIE event is credited with a target kill, The target is then removed from the game plan in much the same manner as in the VANISH and IMPACT events. In addition any unlaunched parasites or in-flight targets dependent on the killed target for guidance signals will be attrited through the use of a VICTIM event type scheduled concurrently with the DIE event (at current game time).

Occurrence of a VICTIM event for an unlaunched parasite involves nothing more than tagging the target as dead and crediting the responsible SAM system with an additional target kill. If the VICTIM event

applies to a dependent in-flight target (e.g., a cruise missile requiring guidance from its launch vehicle), additional action must be taken to remove the target from the game play, again in much the same manner as in the VANISH and IMPACT events.

5.6 Failure, Damage, and Repair of Defensive Units

There are eight event types associated with the failure, damage, and repair of defensive units:

- IMPACT An enemy air-to-surface missile, having a ship in the task force as a target, has detonated;
- DAMAGE An element is damaged by a detonation of an air-tosurface missile;
- FAIL An element fails;
- DOWN An element becomes inoperable because of a DAMAGE or FAIL event;
- REPAIR The repair of an element (for which a DOWN event has occurred) begins;
- UP The repair of an element is complete;
- OFF An element becomes inoperable because either it is down or another element on which the operation of this element depends has become inoperable;
- ON An element becomes operable because the element itself is up and all elements upon which its operation depends are operable.

The relationships linking these event types are indicated in Fig. 5.6-1. In the figure the events are represented by boxes. A solid pointer indicates that one event can possibly generate another event as in the case of an IMPACT event generating one or more DAMAGE events, but a dashed pointer indicates that an event can possibly cancel another event. An example of the latter is that a DOWN event can cancel an UP event which has been scheduled by an REPAIR event (the repair has begun but is not yet complete).

Each ship in the task force is represented by a collection of elementary costing units, referred to as elements. Examples of elements include a propeller shaft, a fire-control computer, a launcher rail, a radar antenna, a radar system, and an entire ship. In these examples the components are not necessarily mutually exclusive. In fact many shipboard systems are represented conveniently by elements that are not mutually exclusive.

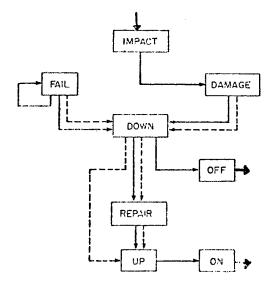


Fig. 5.6-1 - Relations among events. Solid pointers indicate possible generation, and dashed pointers indicated possible cancellations.

In terms of the model an element is an abstraction described by various parameters detailing its location, reliability, and vulnerability as well as its functional dependency upon other elements. It is assumed that each element can be treated as a point object for the purposes of damage assessment.

As the play of the game progresses, an element may have become inoperable for one of three reasons: the element may have been damaged
by the detonation of an enemy missile that has penetrated the fleet's
defenses, the element may have failed randomly, or another element on
which the operation of this element depends may have become inoperable.
If an element becomes inoperable, any other elements whose operation depends on that element will remain inoperable at least as long as it does.
Given that no additional elements fail or are damaged, the cost of the
element becoming inoperable is the cost of restoring it to operational
status plus the mission-dependent cost associated with it.

During the play of a game elements become operable and inoperable as elements fail or are damaged and repairs occur. Concurrently the cost to the fleet of these events is computed, and the defensive capability of the fleet is reflected through the operability states of sets of elements representing ships in the fleet. The occurrence of any one of the event types above represents an incident that has a significant effect on the cost calculation and/or the general operability of the fleet. A detailed discussion of the calculations involved in each of these event types is contained in Ref. 3.

5.7 Disablement Events

There are three disablement-event types: DISRDR, DISCHN, and DISLAN.

Whenever an OFF event occurs for a surveillance radar, a guidance radar channel, or a missile launcher, a DISRDR, DISCHN, or DISLAN event will be scheduled as appropriate. The DISRDR event disables the specified surveillance radar set and cancels any of its currently held primary detections (through the use of the LOSE event type discussed previously). The periodic scan of the radar is inhibited, and no further detection events are related to the radar while it is disabled.

The DISCHN and DISLAN events disable the specified guidance channel and launcher, respectively, and cancel or modify any currently held missile assignments affected thereby. In addition to the effects on current SAM assignments, disablement of guidance channels will affect future weapon availability as reflected in the guidance channel constraint expressions, where the (scalar) number of currently active channels is a factor in these expressions. Similarly, disablement of a SAM missile launcher will affect the future availability of the weapon system of which it was a component part. The occurrence of an ON event however for any of these elements restores its availability to the game.

REFERENCES

- [1] M.E.B. Owens, "An Air-to-Surface Missile Impact Model for Application in Anti-Air Warfare Gaming," NRL Memorandum Report 2380, Jan. 1972.
- [2] L. Davis, "A Simulation of Weapon Systems, Threat Evaluation, and Weapon Assignment in Anti-Air Warfare," NRL Report 7594, Aug. 1973.
- [3] M.E.B. Owens, "A Cost Model for the Assessment of the Effects of Vulnerability and Reliability in Anti-Air Warfare," NRL Report 7582, Aug. 1973.
- [4] O.F. Forsyth and J.J. Penick, "Documentation for the NWRC/AAWG-71 AAW Simulation Model," Naval Warfare Research Center Research Report, July 1971.

Appendix A
INPUT CARD FORMATS

defines exactly one defense unit (ship or AEW aircraft) and refers to the previously defined ship types by an index calue. Card Types SR and SL are used to specify sector constraints for the surveillance radars and missile launchers on defense units as appropriate. Unless otherwise specified, a default value of 360° coverage is assumed for each radar and each launcher. Similarly Card Types OR and OG specify radar simulation model options for surveillance radars and guidance channel groups. Simulation model option 1 is assumed as a default value. Card Types CM and CS modify the default conditions for the intership communications links.

If impacting weapons are included in the raid structure, then at least one weapon profile must be defined with Card Type RW. A Master Flight Path (Card Types RM and RMF) must be defined prior to the generation of any offense units. An MFP may have from two to 15 nodes, describing a piecewise linear flight path in three dimensions. Nonimpacting targets (Card Type RA) travel along the most recently defined MFP, with displacements as specified for each individual target. Parasite or impacting targets (Card Type RAP) must follow directly behind their parent launch planes in the input deck. An example of the use of the card types defined in this appendix is presented in Appendix H.

Card Types TST, TSV, and RAP* (a modification of RAP) are unique to the TDHS version of the model and have been placed in italics.

Table Al - PGP Input Card Types

| Card Page Port Page | | | γ | Table Al - PGP Input Card Types | | , |
|--|-------|-----------|-----------|------------------------------------|--------|--------|
| Commerce | | | | Purnose | | |
| TYPCEN | Туре | Routine | Routine | rarpose | Format | Number |
| TYPCEN | С | GENER8 | GENER8 | Pregame processor control | 1 | A- 4 |
| MPF NSIGEN NSIG | | | | • | | |
| MSIGEN | | | | | | 1 |
| MSIGEN | | MSLGEN | MSLGEN | | 2 | A- 12 |
| TYPGEN | TMT | MSLGEN | MSLGEN | Time-of-flight data | 2 | A- 14 |
| TYPGEN | TMT. | MSLGEN | MSLGEN | | | |
| TPO | | | 1 | | | |
| TPO | 11 | LIFGEN | CHIFGEN | | 1 | A- 20 |
| THE | TPO | CMPGEN | CMPGEN | | 3 | A- 24 |
| TYPGEN | זיזי | TVDCEN | I CUCEN | Tourshow time | , | . 26 |
| RDRGEN RDRGEN RDRGEN Real parameters 3 3 3 3 3 3 3 3 3 | | IIFGEN | LUNGEN | | | A- 26 |
| TRF | | | • | | | |
| TYPGEN GCGEN GCG | TRI | RDRGEN | RDRGEN | | 3 | A- 30 |
| CCCEN CCCE | TRF | RDRGEN | RDRGEN | Real parameters | 2 | A- 34 |
| GCGEN GCGEN GCGEN GCGEN Constraint vector 3 A - 44 TGC GCGEN GCGEN Constraint vector 3 A - 44 TGC GCGEN GCGEN Constraint vector 3 A - 44 TE TYPGEN ECMCEN ECM loading group 1 A - 50 TCD CSGEN CSGEN Cross-section group 1 A - 50 TCD CSGEN CSGEN Reflection data 2 A - 54 TS TYPGEN SHPCEN SHP | TG | TYPGEN | GCGEN | G.C.C.G. type header | 1 | A- 38 |
| CCCEN CCCE | | I. | 4 | | | |
| TGA GCGEN CCOSEN Constraint array 3 A - 46 TE TYPGEN ECMCEN ECM loading group 1 A - 48 TC TYPGEN CSGEN Cross-section group 1 A - 50 TS TYPGEN SHPCEN SHPCEN SHPCEN SHPCEN TSR SHPGEN SHPCEN SHPC | | | 4 | - | | |
| TYPGEN | | | | | | |
| TC TYPGEN CSGEN CSGEN CSGEN Cross-section group 1 A - 50 TS TYPGEN SHPGEN SHPGEN SHPGEN 3 A - 54 TS TYPGEN SHPGEN SHPGEN SHPGEN 3 A - 58 TSG SHPGEN SHPGEN SHPGEN SHPGEN SHPGEN 3 A - 64 TSG SHPGEN SHPGEN SHPGEN Component data 3 A - 64 TSS SHPGEN SH | IGA | GUGEN | GCGEN | Constraint array | ا | A- 46 |
| TCD | TE | TYPGEN | ECMGEN | ECM loading group | 1 | A- 48 |
| TCD | TC | TYPGEN | CSCEN | Cross-section group | 1 | A- 50 |
| Type | | | | | | |
| SECOND SHPCEN SHPCEN SHPCEN Search-radar configuration 3 | | | | | | |
| TSC | | 1 | | | | |
| TSC | TSR | SHPGEN | SHPGEN | Search-radar configuration | 3 | A- 58 |
| TSC | TSG | SHPGEN | SHPGEN | Weapons configuration | 3 | A- 60 |
| SHF | TSC | SHPGEN | SHPGEN | | | A- 64 |
| SECON SECO | | | | | | |
| TST | | | | | | |
| TSV SHPGEN SHPGEN Component vulnerability (TDHS) 3 A-78 TSX SHPGEN SHPGEN Ship-type trailer card 1 A-80 TT TYPGEN TGTGEN Target type 1 A-82 TX TYPGEN TYPGEN Trailer card 1 A-86 BF BOLGEN BOLGEN Boolean function card 7 A-92 BX BOLGEN BOLGEN Boolean function card 7 A-92 BX BOLGEN BOLGEN Boolean function card 7 A-92 BX BOLGEN BOLGEN Boolean function card 7 A-94 DF DEFGEN DEFGEN Boolean function trailer card 4 A-96 DX DEFGEN DEFGEN Defense unit 4 A-76 X SECGEN SECGEN Radar sector 3 A-106 X SECGEN SECGEN Trailer card 6 A-112 X SECGEN OP | | | | | | |
| TSX SHPGEN ShPGEN Ship-type trailer card 3 A-80 TT TYPGEN TGTGEN Target type 1 A-82 TX TYPGEN TYPGEN Trailer card 1 A-86 BF BOLGEN BOLGEN Boolean function card 7 A-92 BK BOLGEN BOLGEN Boolean function trailer card 7 A-92 DF DEFGEN BOLGEN Boolean function trailer card 7 A-92 DF DEFGEN DEFGEN Boolean function trailer card 4 A-94 DF DEFGEN DEFGEN Boolean function trailer card 4 A-94 DF DEFGEN DEFGEN Defense unit 4 A-94 DF DEFGEN DEFGEN Defense unit 4 A-100 SR SECGEN SECGEN Radar sector 3 A-102 SK SECGEN SECGEN Trailer card 6 A-112 OR OPTGEN | | | | | | • - |
| TT TYPGEN TGTGEN Target type 1 A- 82 TX TYPGEN TYPGEN Trailer card 1 A- 86 BF BOLGEN BOLGEN Boolean function card 7 A- 88 BFC BOLGEN BOLGEN Boolean function card 7 A- 92 BX BOLGEN BOLGEN Boolean function trailer card 7 A- 94 DF DEFGEN DEFGEN Boolean function trailer card 4 A- 94 DF DEFGEN DEFGEN Defense unit 4 A- 96 DX DEFGEN DEFGEN Defense unit 4 A- 96 SECGEN Tailer card 6 A-112 OR OPTGEN OPTGEN OPTGEN Option for radars 6 A-112 OC OPTGEN | TSV | SHPGEN | | Component vulnerability (TDHS) | | A- 78 |
| TX TYPGEN TYPGEN Trailer card 1 A- 86 BF BOLGEN BOLGEN Boolean function card 7 A- 88 BFC BOLGEN BOLGEN Boolean function continuation card 7 A- 92 BX BOLGEN BOLGEN Boolean function trailer card 7 A- 94 DF DEFGEN DEFGEN Defense unit 4 A- 96 DK DEFGEN DEFGEN Trailer card 4 A- 100 SR SECGEN SECGEN Radar sector 3 A- 102 SL SECGEN SECGEN Launcher sector 3 A- 106 SX SECGEN SECGEN Launcher sector 3 A- 106 SX SECGEN SECGEN Trailer card 6 A- 112 OR OPTGEN OPTGEN Option for radars 6 A- 112 OC OPTGEN OPTGEN Option for guidance-channel groups 6 A- 114 CS COMGEN | TSX | SHPGEN | SHPGEN | Ship-type trailer card | 3 | A- 80 |
| BF BC BOLGEN GOVERNOON TO A - 94 7 A - 94 DF DEFGEN GOVERN | TT | TYPGEN | TGTGEN | Target type | 1 | A- 82 |
| BFC BOLGEN BOLGEN BOLGEN Bolean function continuation card BX BOLGEN BOLGEN Bolean function trailer card 7 A- 94 DF DEFGEN DEFGEN DEFGEN DEFGEN DEFERN DEFGEN DEFERN DEFGEN DEFGEN Trailer card 4 A-100 SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN Trailer card 6 A-112 OC OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN Trailer card 6 A-116 CM COMGEN COMGEN COMMEN COMMEN Communications-link modification 6 A-118 CS COMGEN COMGEN COMMEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header MFPGEN MFP Data 5 A-136 RA RAIDGN ACGEN ACGEN ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | TX | TYPGEN | TYPGEN | Trailer card | 1 | A- 86 |
| BFC BOLGEN BOLGEN BOLGEN Bolean function continuation card BX BOLGEN BOLGEN Bolean function trailer card 7 A- 94 DF DEFGEN DEFGEN DEFGEN DEFGEN DEFERN DEFGEN DEFERN DEFGEN DEFGEN Trailer card 4 A-100 SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN Trailer card 6 A-112 OC OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN OPTGEN Trailer card 6 A-116 CM COMGEN COMGEN COMMEN COMMEN Communications-link modification 6 A-118 CS COMGEN COMGEN COMMEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header MFPGEN MFP Data 5 A-136 RA RAIDGN ACGEN ACGEN ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | BF | BOLGEN | BOLGEN | Boolean function card | 7 | A- 88 |
| BX BOLGEN BOLGEN Boolean function trailer card 7 A- 94 DF DEFGEN DEFGEN Defense unit 4 A- 96 DX DEFGEN DEFGEN Defense unit 4 A- 100 SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Trailer card 6 A-110 OR OPTGEN OPTGEN Option for radars 6 A-112 OC OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Option for guidance-channel groups 6 A-116 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN Environmental data 2 A-136 EX E | | | | | | |
| DX DEFGEN DEFGEN Trailer card 4 A-100 SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Launcher sector 3 A-110 OR OPTGEN OPTGEN Option for radars 6 A-112 OR OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 EN ENVGEN Environmental data 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM | | | | | | |
| DX DEFGEN DEFGEN Trailer card 4 A-100 SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Launcher sector 3 A-110 OR OPTGEN OPTGEN Option for radars 6 A-112 OR OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 EN ENVGEN Environmental data 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM | | ! | | | | |
| SR SECGEN SECGEN Radar sector 3 A-102 SL SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN OPTGEN Option for radars 6 A-112 OG OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Trailer card 6 A-116 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN Environmental data 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Mster-Flight-Path header 5 A-136 RM RAIDGN <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td></t<> | | | | | | |
| SL SECGEN SECGEN Launcher sector 3 A-106 SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN OPTGEN Option for radars 6 A-112 OG OPTGEN OPTGEN Option for guidance-channel groups 6 A-114 OX OPTGEN OPTGEN Trailer card 6 A-116 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link modification 6 A-122 CX COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 2 A-124 EN ENVGEN Environmental data 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Mster-Flight-Path header 5 A-136 RM RA | DX | DEFGEN | DEFGEN | Trailer card | 4 | A-100 |
| SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN Trailer card 6 A-114 CM COMGEN COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN ENVGEN Environmental data 2 A-128 EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN MASter-Flight-Path header MFPGEN MFP Data 5 A-136 RA RAIDGN ACGEN ACGEN Offense unit 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | SR | SECGEN | SECGEN | Radar sector | | A-102 |
| SX SECGEN SECGEN Trailer card 3 A-110 OR OPTGEN Trailer card 6 A-114 CM COMGEN COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN ENVGEN Environmental data 2 A-128 EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN MASter-Flight-Path header MFPGEN MFP Data 5 A-136 RA RAIDGN ACGEN ACGEN Offense unit 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | SL | | | Launcher sector | 3 | A-106 |
| OC OPTGEN OPTGEN OPTGEN Trailer card 6 A-114 CM COMGEN COMGEN COMMEN Communications-link modification 6 A-122 CX COMGEN COMGEN COMMEN | | | | | | |
| OC OPTGEN OPTGEN OPTGEN Trailer card 6 A-114 CM COMGEN COMGEN COMMEN Communications-link modification 6 A-122 CX COMGEN COMGEN COMMEN | OR | ОРТСЕМ | ОРТСЕМ | Ontion for radars | 6 | A-112 |
| OX OPTGEN OPTGEN Trailer card 6 A-116 CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVIGEN Environmental data 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RM RAIDGN MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP* ACGEN ACGEN Parasite data 5 A-148 | | | | | | |
| CM COMGEN COMGEN Communications-link modification 6 A-118 CS COMGEN COMGEN Communications-link initial status 6 A-122 CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN ENVGEN Environmental data 2 A-128 EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RMG MFPGEN MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | | | | |
| CS COMGEN COMGEN COMGEN Communications-link initial status 6 A-122 EN ENVGEN ENVGEN ENVGEN ENVGEN ENVGEN Trailer card Environmental data 2 A-128 EX ENVGEN ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN MSter-Flight-Path header MFP Data 5 A-136 RA RAIDGN MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN ACGEN ACGEN Parasite data 5 A-142 RAP* ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 | UX. | OPIGEN | OFIGEN | Trailer card | O | W-110 |
| CS COMGEN COMGEN COMGEN Communications-link initial status 6 A-122 EN ENVGEN ENVGEN ENVGEN ENVGEN ENVGEN Trailer card 2 A-128 EX ENVGEN ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFFGEN MSTFGEN MSTFGEN MFP Data 5 A-136 RM RAIDGN MFFGEN MFP Data 2 A-138 RA RAIDGN ACGEN ACGEN ACGEN Parasite data 5 A-142 RAP* ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 | СМ | COMGEN | COMGEN | Communications-link modification | 6 | A-118 |
| CX COMGEN COMGEN Trailer card 6 A-124 EN ENVGEN ENVGEN Environmental data 2 A-130 EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RM MFPGEN MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | | Communications-link initial status | 6 | A-122 |
| EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RMC MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | 1 | | | |
| EX ENVGEN ENVGEN Trailer card 2 A-130 RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RMC MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | | | | |
| RW RAIDGN WPNGEN Weapon profile data 5 A-132 RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RMG MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | ENVGEN | | | |
| RM RAIDGN MFPGEN Master-Flight-Path header 5 A-136 RMG MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data for TDHS version 5 A-148 | EX | ENVGEN | ENVGEN | Trailer card | 2 | A-130 |
| RMG MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 | RW | RAIDGN | WPNGEN | Weapon profile data | 5 | A-132 |
| RMG MFPGEN MFP Data 2 A-138 RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN ACGEN Parasite data for TDHS version 5 A-148 | nw l | DATEON |) Amponie | Washing Wildship Dakk hands | _ | 1-124 |
| RA RAIDGN ACGEN Offense unit 5 A-142 RAP ACGEN ACGEN Parasite data 5 A-144 RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | i i | | | |
| RAP ACGEN ACGEN Parasite data RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-144 A-148 | IV.19 | fir FGEN | FIFFGEN | rri Data | - | V-130 |
| RAP ACGEN ACGEN Parasite data RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-144 A-148 | RA | RAIDGN | ACGEN | Offense unit | 5 | A-142 |
| RAP* ACGEN ACGEN Parasite data for TDHS version 5 A-148 | | | | | | |
| | | | | | | |
| AA RAIDSN RAIDSN ITALIEF CAFG | , pv | DA TINOST | DATIVE | Twofler card | _ | A-152 |
| | KΛ | KALIJGN | KALUGN | Trailer card | | W-134 |

| | FOR:JAT | LOCAL LABEI | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|---------|----------------|-----------------------|---------|---|-------------------------|--|------------------|--|
| 11 2 3 | ဂ | | | | Label | N/A | 1 2 3 | FORMAT | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | R | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 35 33 30 40 41 42 43 44 45 46 47 48 49 50 5 15 2 53 54 55 | (20H) | (ACARD) | (Alpha) | | Run Identifier | RUNID(I), I=1,N2OECD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | I READING GENERS | C PURPOSE Pregame Processor Control Card |
| 26 27 28 29 30 | (15) | | | | (Unused) | | 26 27 28 29 30 | ROUTINE | ontrol Car |
| 31 32 33 34 35 | (51) | MREAD | 0 or 1 only | integer | Existing "TYPE DATA" is to be read in from Tape prior to the start of the Type Generator | n/A | 31 32 33 34 35 | GENER8 | ď. |
| 36 37 38 39 40 | (15) | (MLIST) | 0 or 1 | | Input Summary Listing is to include only new (0) or all (1) of the Type Data | MLIST | 36 37 38 39 40 | 8 | |
| 41 42 43 44 45 | (21) | типт эт | 0 or 1 only | | The "TYPE DATA" is (1) or is not (0) to be written onto Tape after the Input Summary is completed | · n/A | 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | REMARKS | |
| 46 47 48 49 50 | (15) | (0808M) | 0 or 1 | integer | Pseudo 80-80 Listing of Input Cards is (1) or is not (0) to be made | M8080 | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | MREPL | ≥ 0 | integer | The number of existing "REPLICATION FILES" to be saved on the Type-and-Replication Tape (if MWRITE $\neq 0$, then MREPL $\leftarrow 0$) | n/A | 5152535455 | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | | |
| 6162636465 | (15) | | | | | | 51 62 63 54 65 | | |
| 56 57 58 59 50 61 62 63 64 65 56 57 68 69 70 71 72 73 74 75 76 77 78 7980 | (15) | | | | | | 36 57 58 59 60 51 62 63 54 65 65 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 71 72 73 74 75 | (15) | | | | | | 71 72 73 74 75 | | . 1 Of |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 90 | | 1 |

| Card Columns | <u>Description</u> |
|--------------|--|
| 1 | The label "C" indicates that this card is the Pregame Processor control card. |
| 6-25 | 20-character field identifying the input data set—this field is written as the first record on the replication data file. It may be used later to readily identify a file on tape and it also appears on the game execution package summary listings. |
| 26-30 | These card columns are presently unused. |
| 31-35 | A value of 0 or blank indicates that Type data are to be read from cards only; a value of 1 indicates that Type data are to be read from tape and may or may not be supplemented with Type data from cards. |
| 36-40 | Option controlling the printing of Type data where the value 0 or blank means include only the newly defined types (i.e., those types read from the card reader file) in the input summary, and a value of 1 means print all types for which there is data. |
| 41-45 | A value of 0 or blank indicates that Type data are not to be written on tape; a value of 1 indicates that a Type data file is to be written if the data are found to be error free. If a Type data file is written, an existing file will be lost since the new file overwrites the old one. |
| 46-50 | Print option where the value 1 means produce a single-spaced listing of all card inputs, printing each card with the same format used for reading the card (which |

Amplification of Card Type C (Concluded)

Card Columns

Description

means it is not truly an 80-80 listing since the formats are not strictly FORTRAN A-type conversion); a value of 0 or blank means this listing is not desired.

51-55

A value of 0 means that no replication data files are to be saved so that replication data for this game will be on the second file (the first file is always the Type data). A nonzero value specifies the number of existing replication files to be saved. Note that a value of zero (0) will be assumed if a request is made to rewrite the Type data--it would be unwise to expect that the new Type data file has exactly overwritten the old file.

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| | FORMAT | LABEL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | 1 | | |
|---|--------|------------|-----------------------|---------|--|----------------------------------|---|------------------|-------------------------------------|
| 1 2 3 | T M | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | RAT | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 58 | (20н) | (ACARD) | (Alpha) | | Missile Type name | MSLTNM (I,NMT), I=1,N2OBCD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | 1 READING TYPGEN | TM PURPOSE Missile Type Header Card |
| 5 26 27 28 29 30 | (15) | NMT | 1 to NMTMAX | integer | Missile Type number | n/a | 26 27 28 29 30 | HOUTINE | er Card |
| 31 32 33 34 35 | (15) | NPE | 3 to 9 | integer | Number of performance envelope nodes | MSLPAR (NMT) | 31 32 33 34 35 36 37 38 39 40 | MSLGEN | |
| 36 37 38 39 40 | (15) | МТ | 1,2, or 3 only | integer | Option number for Time of Flight Data | MSLPAR (NMT) | 36 37 38 39 40 | EN | |
| 41 42 43 44 45 | (15) | TN | 1 to 7 | integer | Row dimension for Time of Flight Data | MSLPAR _e (NMT) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | N 2 | 1 to 7 | integer | Column dimension for Time of Flight Data | MSLPAR _f (NMT) | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | ML | l or 2 only | integer | Option number for Missile Lethality Data | MSLPAR (NMT) | 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 56 | (15) | N3 | 1 to 15 | integer | Number of entries in Missile Lethality Data | MSLPAR _h (NMT) | 26 | | |
| 61 62 63 64 65 | (15) | NC | 1 to 1000 | integer | Cost per unit missile in thousands of dollars | mslpar (nmt) | 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 71 72 73 74 75 | (15) | | | | | | 7172737475 | | E 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | F 4 |

Amplification of Card Type TM

| Card Columns | Description | | | | | |
|--------------|--|--|--|--|--|--|
| 1-2 | The label 'TM" indicates that this card is a missile type header card. | | | | | |
| 6-25 | 20-character field which may be used to assign a name to the missile type being defined. | | | | | |
| 26-30 | Identification number (NMT) for this missile type. | | | | | |
| 31-35 | The number of nodes of the convex polygon describing the performance envelope of missile type NMT. The nodes are listed in counterclockwise order and define the boundary of a vertical section of the performance envelope. | | | | | |
| 36-40 | option number for time of flight data. The available options are: | | | | | |
| | Option 1: $T_f(H, \sin \theta) = \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} \left\{ A(i,j)H^{j-1}[\sin \theta]^{i-1} \right\}$ | | | | | |
| | Option 2: $T_f(H,Z) = \sum_{i=1}^{N_1} \sum_{j=1}^{N_2} \left\{ A(i,j)H^{j-1}Z^{i-1} \right\}$ | | | | | |
| | Option 3: $T_f(H,Z) = \frac{(H^2 + Z^2)^{\frac{1}{2}}}{A_{i,j}}$ | | | | | |

where H = Horizontal range from missile launcher to target

 θ = Vertical angle to the target relative to a horizontal plane passing through the missile launch position

Card Columns

Description

A = matrix of polynomial coefficients (for Options 1 and 2), or altitude, range, and average speed values (for Option 3)

 N_1 = number of rows in matrix A (2 \leq N₁ \leq 7)

 N_2 = number of columns in matrix A (2 \leq N_2 \leq 7)

z = altitude of target above the missile launcher

 $A_{i,j}$ = an average missile speed such that

$$\begin{cases} A(i-1,1) < Z \le A(i,1), 2 \le i \le N_1 \\ A(1,j-1) < H \le A(1,j), 2 \le j \le N_2 \end{cases}$$

A(1,1) = 0 for Option 3.

41-45 The value of N_1 as defined for Options 1, 2, and 3 above.

46-50 The value of N_2 as defined for Options 1, 2, and 3 above.

Option number for missile lethality data. The general form is a 3-tuple (p_{1i},p_{2i},p_{3i}) associated with each vulnerability group i. The options are:

Option 1: $p_{1i} = P_{K}(i)$

= P{Kill | target in vulnerability group i}

 p_{2i} = $1/\lambda_{i}$ = mean time to die (after missile-target intercept) for a target in vulnerability group i. A negative exponential distribution is utilized so that the time interval from intercept to target death is:

Card Columns

Description

$$T_{D}(i) = p_{2i} \left[ln \left(\frac{1}{1-\rho} \right) \right]$$

where ρ = a uniform random number sample.

p is unused for Option 1:

Option 2: $p_{1i} = P_{K}(i)$

= P{Kill | target in vulnerability group i}

 P_{2i} = $\mu(i)$ = mean of the underlying normal distribution for a log normal time to die distribution

 $P_{3i} = \sigma(i) = standard deviation of the underlying normal distribution for a log normal time to die distribution.$

- 56-60 The number, N3, of vulnerability groups (the number of 3-tuples) for which there are lethality data defined for this missile type.
- 61-65 Cost per unit missile of this type expressed in thousands of dollars.

| | FORMAT | LABEL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION |] | |
|--|---------|----------------|-----------------------|-------|---|-----------------------|---|--------------------|
| 11 2 3 | H | | ς m | | Label | N/A | NUMBER | CARD NAME |
| 4 5 | ī | 1 | † | T | (Unused Integer) | N/A | 1 SER | AAT E |
| 6 7 8 | | FLTARY(1) | ≥ 0 | kft | Missile minimum intercept range (first performance envelope node is assumed to be at 0,0) | PRFENV (1,1,NMT) | 2 ROUTINE | ď |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (F10.3) | FLTARY(2) | ≥ 0 | kft | Missile maximum intercept range | PRFENV (2,1,NMT) | MSLGEN 16 17 18 19 20 21 22 23 24 25 | Performance Envelo |
| 26 27 28 29 30 31 32 33 34 35 | (F10.3) | FLTARY(3) | 0 ≥ | kft | Range to performance envelope node #2 | PRFENV (1,2,NMT) | MSLGEN ROUTINE MSLGEN REMARKS 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | for Mi |
| 36 37 38 39 40 41 42 43 44 45 | (F10.3) | FLTARY(4) | ≥ 0 | kft | Altitude at performance envelope node #2 | PRFENV (2,2,NMT) | N N NEWARKS | ⊣ ′ I |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | FLTARY(5) | ≥ 0 | kft | Range to performance envelope node #3 | PRFENV (1,3,NMT) | 46 47 48 49 50 51 52 53 54 55 | |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 65 57 58 59 50 61 62 63 64 66 66 67 68 69 70 71 72 73 74 75 06 77 78 79 80 | (F10.3) | • | | | (Continue as required on up to two additional cards) | • | 8 | |
| 36 67 68 69 70 71 72 73 74 75 | (F10.3) | FLTARY (2*NPE) | ₽ 0 | kft | Altitude at performance envelope #NPE | PRFENV (2,NPE,NMT) | 2*NPE ≤ 18 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | PAGE 2 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | 4 |

Amplification of Card Type TMP

Repeat as many cards of this type (up to 3 cards) as is necessary to describe all of the missile type performance envelope nodes. Each card must have the letters TMP in columns 1-3. The nodes are given in terms of range and altitude, both in thousands of feet, and are listed in counterclockwise order. The fields used for the first node (i.e., columns 6-15 and 16-25 of the first card) are used to describe the missile type minimum and maximum intercept range, respectively, since the first node is assumed to be at (0,0). The nodes describe a vertical-half-plane section through the missile type's performance envelope and are assumed to define a convex polygon.

| | _ | | | | | | 3 | | |
|---|---------|----------------|-----------------------|---------|--|--------------------|--|------------------|----------------------|
| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | тмт | | | | Label | n/A | 123 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | 33 13 | . 1 |
| 6 7 | (F10.3) | FLTARY(1) | ≥ 0 | seconds | Time of Flight Data for Row 1, Column 1 (interpretation of data depends on option "MT" on "TM" card) | TOF (1,1,NMT) | 6 7 8 9 1011 12 13 14 15 | 2 READING | TMT |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (F10.3) | FLTARY(2) | ≥ 0 | seconds | Row 2, Column 1 | TOF (2,1,NMT) | 16 17 18 19 20 21 22 23 24 25 | MSLGEN | Time of Flight Data |
| 26 27 28 29 30 31 32 33 34 36 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (F10.3) | • | | • • • | • | • | 26 27 28 29 30 31 32 33 34 35 | USING MSLGEN | for Missile Type NMT |
| 36 37 38 39 40 41 42 43 44 45 | (F10.3) | fltary(n1) | 0 ح | seconds | Row Nl, Column 1 | TOF (N1,1,NMT) | 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | REMARKS | MT |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | FLTARY (N1+1) | ≥ 0 | seconds | Row 1, Column 2 | TOF (1,2,NMT) | 46 47 48 49 50 51 52 53 54 55 | | |
| 1 | (F10.3) | • | | ••• | (Continue as required on up to six additional cards) | • | 56 57 58 59 60 61 62 63 64 65 | (N1*N2) ≤ 49 | |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 7 6 77 78 79 80 | (F10.3) | FLTARY (N1*N2) | ≥ 0 | seconds | Row N1, Column N2 | TOF (N1,N2,NMT) | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 3 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 44 |

Amplification of Card Type TMT

Repeat as many cards of this type (up to 7 cards) as is necessary to describe all of the elements of the missile type time of flight data array. Each card must have the letters TMT in columns 1-3. The elements of the data array must be listed columnwise, i.e.,

$$\{A(1,1), A(2,1), \dots, A(N_1,1), A(1,2), A(2,2), \dots, A(N_1,2), \dots, A(N_1,N_2)\}$$

For Options 1 and 2 (see Card Type TM) the array elements, A(i,j), are interpreted as polynomial coefficients. For Option 3 the array is interpreted as follows:

$$A = \begin{bmatrix} 0 & R_{2} & R_{3} & \cdots & R_{N_{2}} \\ Z_{2} & S_{2,2} & S_{2,3} & \cdots & S_{2,N_{2}} \\ Z_{3} & S_{3,2} & S_{3,3} & \cdots & S_{3,N_{2}} \\ \vdots & \vdots & \vdots & & \vdots \\ Z_{N_{1}} & S_{N_{1},2} & S_{N_{1},3} & \cdots & S_{N_{1},N_{2}} \end{bmatrix},$$

where

$$A_{11} = 0$$
 (always)

S = an average speed value used to compute missile time of flight for an intercept at range R and altitude Z such that

$$z_{i-1} < z \le z_{i},$$
 $x_{i-1} < x \le x_{i}.$

Amplification of Card Type TMT (Concluded)

Note that for Option 3, the value of $Z_{N_1} = A(N_1,1)$ must be at least as large as the maximum intercept altitude allowed by the missile type performance envelope. Similarly, $R_{N_2} = A(1,N_2)$ must be at least as large as the maximum intercept range.

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| П | | | | | | | 1 | | |
|--|--------|------------------|-----------------------|---------|--|--------------------------|---|--------------------|-----------|
| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | TML | | | | Label | N/A | 123 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | ₽Å | ار |
| 6 7 8 9 10 11 | (15) | INTARY (1) | 0 to 100 | percent | Lethality Parameter, p ₁₁ | MSLPK (NMT) | 6 7 8 9 10 | 3 | TML |
| 11 12 13 14 15 | (15) | INTARY (2) | ≥ 0 | seconds | ^p 21 | MSLPK (NMT) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (51) | INTARY (3) | 0 ح | seconds | ^р 31 | MSLPK (NMT) | 16 17 18 19 20 | MSLGEN | Lethality |
| 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | INTARY (4) | 0 to 100 | percent | ^p 12 | mslpk _d (nmt) | 21 22 23 24 25 | | Data for |
| 26 27 28 29 30 | (15) | INTARY (5) | ≥ 0 | seconds | p ₂₂ | MSLPK _e (NMT) | 26 27 28 29 30 31 32 33 34 35 | USING ROUTINE | Missile T |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 | (15) | INTARY (6) | ≥ 0 | seconds | р ₃₂ | mslpk _f (nmt) | 31 32 33 34 35 | MSLGEN | Type NMT |
| 36 37 38 39 40 | (15) | INTARY (7) | 0 to 100 | percent | ^p 13 : | MSLPK (NMT) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (51) | • • | | | • | • | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | • • • | | | (Continue as required on up to three additional cards) | • | 46 47 48 49 5051 52 53 54 55 | | |
| 51 52 53 54 55 | (15) | • | | | • | • | 51 52 53 54 55 | | |
| 56 57 58 59 60 | (15) | INTARY (3*N3) | 0 | seconds | P3,"N3" | mslpk _* (nmt) | 56 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 51 62 63 64 65 | (3*N3) ≤ 45 | |
| i6 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 68 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 71 72 73 74 75 | (15) | | | | | | /1 /2 /3 /4 /5/ | | 4 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 6 // /8 /9 80 | | μ4 |

Amplification of Card Type TML

Repeat as many cards of this type as is necessary to describe a lethality 3-tuple for each of the N3 vulnerability groups specified on Card Type TM. Interpretation of the lethality 3-tuples within the simulation model will be in accordance with the option number specified in columns 51-55 of the Card Type TM, and each Target Type will be assigned to a vulnerability group on Card Type TT (columns 31-35).

| | FORMAT | LABEL | OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|---------|----------------|------------------|-----------------------------------|--------------------------------|--|------------------|-------------------------|
| 1 2 3 | Ţ.P | | | | Label | N/A | 1 2 3 | FORMAT | CARD |
| 5 | | | | | (Unused Integer) | N/A | S | - 1 | J |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 | | (ACARD) | (Alpha) | | Component Type Name | CMPTNM (I, ICT), I = 1, N20BCD | 6 7 8 9 1011 12 13 14 15 16 | 1 READING TYPGEN | TP PUHPOSE Component Ty |
| 2 23 24 25 | | | | | | | | | Type Header Card |
| 26 27 28 29 30 | (15) | ICT | 1 to NCTMAX | integer | Component Type Number | N/A | 8 | DSING | r Card |
| 31 32 33 34 35 | (15) | | ≥ 0 | qtr. hr. | Expected Time between Failures | ICTPAR _C (ICT) | 31 32 33 34 35 | CMPGEN | |
| 36 37 38 39 40 | (51) | | ≥ 0 | thou. dollars | Replacement Cost | ICTPAR _d (ICT) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | 0 to 1000 | integer | E[R] x 1000 for Vulnerability | ICTPAR _e (ICT) | 36 37 38 39 40 41 42 43 44 45 | REMARKS | |
| 27 28 29 30(31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 57 53 54 55 56 | (15) | | 0 to 1000 | integer | k x 1000 for Variance of R | ICTPAR _f (ICT) | 46 47 48 49 50 51 52 53 54 55 | | |
| 5152535455 | (15) | | 0 to 1000 | integer | E[R] x 1000 for Failure | | | | |
| 56 57 58 59 50 | (15) | | >0 | winutes | Expected repair delay time | | 56 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | ≥0 | seconds | Expected time to die | ICTPAR ₁ (ICT) | 57 58 59 60 61 62 63 64 69 | | |
| 66 67 68 69 70 | (15) | | >>0 | seconds | Standard Deviation of time to die | ICTPAR _j (ICT) | 66 67 68 69 70 | - | PAGE |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | ≥0 | dollars/ | Expected repair rate | ICTPAR _k (ICT) | 66 67 68 69 7d 71 72 73 74 75 76 77 78 79 80 | | E 1 OF |
| 76 77 78 79 80 | (5X) | | ≥ 0 | dollars/ | Standard deviation of repair rate | ICTPAR ₁ (ICT) | 76 77 78 79 80 | | 2 |

Amplification of Card Type TP

A component may be considered to be any entity associated with a ship (or defense unit) whose functioning may be essential to the operation of other shipboard elements and whose failure and/or damage in battle may contribute a cost to the task force.

| Card Columns | Description |
|--------------|---|
| 1-2 | "TP" label indicating this is a component type data card. |
| 6-25 | 20-character field which may be used to assign a name to this component type. |
| 26-30 | Identification number for this component type, which is used as a reference number when defining components within ship type. |
| 31-35 | Expected time between spontane- ous failures of this component type, given in quarter hours. |
| 36-40 | Replacement cost of a component of this type, expressed in thousands of dollars. |
| 41-45 | Vulnerability factor of E[R] x 1000, where R is the percentage cost in terms of current value of a component of this type, and the expectation of R is calculated given that the peak overpressure the component sustains is the reference peak overpressure defined below. |
| 46-50 | Variance of R factor of K x 1000, where $Var[R] = K\mu_p(1-\mu_p)$, in which μ_p is the expectation of R given that the peak overpressure is p. |
| 51-55 | Failure factor of E[R] x 1000, where R is the percentage cost in terms of current value of a component of this type. |
| 56-60 | Expected repair delay time, expressed in minutes. |
| | A-21 |

Amplification of Card Type TP Continued

| Card Columns | Description |
|--------------|---|
| 61-65 | Expected time to die, expressed in seconds. |
| 66-70 | Standard deviation of time to die, expressed seconds. |
| 71-75 | Expected repair rate, expressed in dollars/hour. |
| 76-80 | Standard deviation of repair rate, expressed in dollars/hour. |

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| | FORMAT | LABEL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|-----------|-----------------------------|------------------------------|--|--------------------|-----------|
| 11 2 3 | Odi | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| ŝ | (12) | | | | (Unused Integer) | N/A | 5 | ٣٩ | 1 |
| 6 7 8 9 10 | (15) | | | lbs/sq.in | Reference Peak Overpressure | ICTPAR _m (ICT) | 6 7 8 9 10 | | TPO |
| 11 12 13 14 15 | (15) | | | | | | 11 12 13 14 1 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | | | | | 5 16 17 18 19 20 | CMPGEN | Component |
| 21 22 23 24 25 | (15) | | | | | | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | Type |
| 11 1 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 51 32 33 34 35 36 37 36 36 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (15) | | | | | | 26 21 28 29 30 | ROUTINE | data card |
| 31 32 33 34 36 | (15) | | | | | | 11 32 33 34 35 | CMPGEN | |
| 36 37 36 39 40 | (21) | | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 46 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 52 53 54 55 | | |
| | (15) | | | | | | | | |
| 56 57 58 59 50 | (E) | | | | | | 56 57 58 59 60 | | |
| 61 62 63 64 66 | (E) | | | | | | 61 62 63 64 65 | | |
| 56 57 58 59 5061 62 63 64 66 66 67 68 69 7071 72 73 74 75 76 77 78 79 80 | (E) | | | | | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | - | PAGE |
| 1 72 73 7 | (IS | | | | | | 71 72 73 1 | | 2 |
| 4 75 76 | 4 | | | 4 | | | 7576 | 1 | 읶 |
| 77 78 79 80 | SX) | | | | | | 77 78 79 80 | | 2 |

Amplification of Card Type TPO

Card Type TPO is a continuation of component type data, and immediately follows Card Type TP.

| Card Columns | Description |
|--------------|---|
| 1-3 | "TPO" label, indicating this is a continuation component type data card. |
| 6-10 | Reference peak overpressure expressed in pounds/square inch, which is defined to be that overpressure at which the probability the component is damaged is 0.5. |

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|--------|---------|-----------------------|---------|--|----------------------------------|---|------------------|-------------------------------|
| 1123 | ТL | | | | Label | n/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | n/A | 5 | カイ | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20Н) | (ACARD) | (Alpha) | | Launcher Type name | LCHTNM (I,LRT), I=1,N2OBCD | 15 16 17 18 19 20 21 22 23 24 25 | 1 READING TYPGEN | TL PURPOSE Launcher Type Card |
| 26 27 28 29 30 | (15) | LRT | 1 to NLTMAX | integer | Launcher Type number | N/A | 26 27 28 29 30 | ROUTINE | |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 51 | (15) | МТ | 1 to 15 | integer | Missile Type launched by this Launcher Type | LCHPAR (LRT) | 31 32 33 34 35 | LCHGEN | |
| 36 37 38 39 40 | (15) | МС | 1 to 63 | integer | Magazine capacity (number of missiles available) | LCHPAR _d (LRT) | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 63 54 55 56 | | |
| 41 42 43 44 45 | (15) | NR | 1 to 15 | integer | Number of rails on this Launcher Type | LCHPAR _e (LRT) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | NRD | 0 to 63 | seconds | Inter-rail firing delay | LCHPAR _f (LRT) | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | NCD | 0 to 63 | seconds | Cycle time for reload | LCHPAR (LRT) | 51 52 53 54 55 | | |
| | (15) | NBD | 0 to 63 | seconds | Button pushing delay | LCHPAR _h (LRT) | | | |
| 61 62 63 64 65 | (15) | | | | | | 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | 1 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 1 |

Amplification of Card Type TL

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "TL" indicates that this card is a launcher type card. |
| 6-25 | 20-character field which may be used to assign a name to this launcher type. |
| 26-30 | Identification number for this launcher type. |
| 31-35 | Missile type launched by this launcher type (see Card Types TM, TMP, TMT, TML). |
| 36-40 | Capacity of the launcher type's missile magazine. |
| 41-45 | The number of rails on this launcher type. |
| 46~50 | Inter-rail firing delay (i.e., the time that it takes a launcher that has just fired to be ready to fire again, given that at least one loaded rail remains). |
| 51-55 | Cycle time for reload (i.e., the time that it takes a launcher that has just fired a missile from its last loaded rail to be ready to fire again). |
| 56-60 | Button pushing delay (i.e., the time between activation of the launcher firing circuit and the actual firing of a missile salvo). |

| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|---------|-----------------------|---------|---|-----------------------------------|---|----------------------|------------------------------|
| 11 2 3 | 4 | | | | Label | N/A | 1 2 3 | NUMBER NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | 캶 | İ |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | (ACARD) | (Alpha) | | Radar Type name | RDRTNM (I,NRDR), I=1,N20BCD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | 1 READING ROUTINE | TR PURPOSE Radar Type Header |
| 26 27 28 29 30 31 | Г | NRDR | 1 to NRTMAX | integer | Radar Type number | N/A | 26 27 28 29 30 | USING ROUTINE | |
| 32 33 34 35 | (15) | | 1 to 5 only | integer | Radar frequency band index | IRDRPC (NRDR) | 31 32 33 34 35 | RDRGEN | |
| 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (15) | | 0 to 31 | seconds | Target acquisition delay time (for fire control radars) | IRDRPC d (NRDR) | 36 37 38 39 40 | USING RDRGEN REMARKS | |
| 41 42 43 44 45 | (15) | | 0 to 31 | seconds | Kill evaluation delay time (for fire control radars) | IRDRPC (NRDR) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | 0 to 31 | seconds | Surveillance radar scan period | IRDRPC (NRDR) | 46 47 48 49 50 51 52 53 54 55 | | 3 |
| 51 52 53 54 55 | (15) | | > 0 | kft | Maximum unambiguous range (scope limit) | IRDRPC (NRDR) ^g | 51 52 53 54 55 | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | |
| 36 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 71 72 73 74 75 | (15) | | | | | | 7172737475 | | E 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | ω |

Amplification of Card Type TR

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "TR" indicates that this card is a radar type header. |
| 6-25 | 20-character field which may be used to assign a name to this radar type. |
| 26-30 | Identification number (NRDR) for this radar type. |
| 31-35 | Radar frequency band index, where 1, 2, 3, 4, or 5 represent P-, L-, S-, C-, or X-Band respectively. |
| 36-40 | Target acquisition delay time for fire control radars. This delay represents the mean time from assignment of a fire_control radar to a target to the acquisition of the target by the radar. This delay is not applicable to surveillance radar types. |
| 41-45 | Kill evaluation delay time for fire control radars. This delay represents the mean time from intercept of a target to the assessment of the intercept. |
| 46-50 | Surveillance radar scan period. This parameter is not applicable to fire-control radar types. |
| 51-55 | Maximum unambiguous range, or scope limit, in kft. |

| _ | | | | | | | 1 | | |
|--|--------|----------------|-----------------------|-------|--|-----------------------|--|--|---------------------|
| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
| 123 | T R I | | | | Label | N/A | 123 | FORMAT NUMBER | CARD |
| 5 | (12) | - | | | (Unused Integer) | N/A | 5 | 꿈취 | |
| 6 | | INTARY (1) | * | * | lst Integer Parameter for Radar Type NRDR | IRDROP (NRDR) | 678910 | 3 | TRI |
| 7 8 9 10 11 12 13 14 16 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 21 32 33 34 36 28 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 50 67 62 53 54 65 66 7 88 69 70 7 17 23 74 75 76 77 78 79 80 | (15) | INTARY (2) | * | * | 2nd Integer Parameter | IRDROP (NRDR) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | INTARY (3) | * | * | 3rd Integer Parameter | IRDROP (NRDR) C | 16 17 18 19 20 21 22 23 24 25 | RDRGEN | Integer Parameters |
| 21 22 23 24 25 | (15) | INTARY (4) | * | * | 4th Integer Parameter | IRDROP (NRDR) | | | |
| 26 27 28 29 30 | (15) | • | | | • | : | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 49 46 47 48 49 50 51 52 53 54 58 58 | HOUT INE | for Radar Type NRDR |
| 31 32 33 3 4 36 | (15) | | | | (Continue as required for number of Integer Parameters specified for all Simulation Model Options defined) | | 11 32 33 34 35 3 | RDRGEN | Type NRDR |
| 36 37 38 39 40 | (15) | • | | | • | : | 6 37 38 39 40 4 | - | |
| 41 42 43 44 46 | (15) | INTARY (NI) | * | * | NIth Integer Parameter | IRDROP * (NRDR) | 1 42 43 44 45 | REMARKS NI | |
| 46 47 48 49 50 | (15) | | | | | | 6 47 48 49 505 | I = the tor a | |
| 51 52 53 54 55 | (15) | | | | | | 1 52 53 54 55 5 | total numbe all simulat | |
| 6 57 58 59 60 | (15) | | | | | | - 0, | | |
| 61 62 63 64 65 | (15) | | | | | | 57 58 59 60 61 62 63 64 66 66 67 88 69 70 71 72 73 74 75 | of integer parameters required on model options. | |
| 56 67 68 69 70 | (15) | | | | | | 56 6/ 68 69 /0 | eters req | PAGE |
| 71 72 73 74 75 | (15) | | | | | | /1 /2 /3 /4 /5 | | 2 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/a | 76 // /8 /9 80 | 2000 | 3 |

Amplification of Card Type TRI

The fields described below are for radar simulation model Options 1 through 4 which require up to 14 integer values. Other options, not yet defined, may require additional integer values; these would be specified on one or more additional Type TRI cards. The simulation model option for an individual radar set is selected in the Defense Generator.

| Card Columns | Description | |
|--------------|--|--|
| 1-3 | The label "TRI" indicates that this card contains integer parameters for the radar type being processed. | |
| 6-10 | Radar wavelength in centimeters. | |
| 11-15 | Receiver IF noise bandwidth in megahertz. | |
| 16-20 | Transmitter antenna gain in db. | |
| 21-25 | Receiver antenna gain in db. | |
| 26-30 | Sidelobe level in db down from the receiver main beam. | |
| 31-35 | Transmitter losses in db. | |
| 36-40 | Receiver losses in db. | |
| 41-45 | Receiver noise figure in db. | |
| 46-50 | Number of pulses integrated. | |
| 51-55 | False alarm probability factor, a, where a = $-\log_{10}^{P}$ fa | |
| | (i.e., $P_{fa} = 10^{-a}$). | |
| 56-60 | Horizontal antenna pattern function index. | |
| 61-65 | Vertical antenna pattern function index. | |

Amplification of Card Type TRI (Concluded)

Card Columns

Description

66-70

Applicability* of gimbal constraint (gc), raster constraint (rc), and pencil beam constraint (pc) packed as:

100*gc + 10*rc + pc

71-75

Applicability* of closing speed resolution (sr), range resolution (rr), horizontal angle resolution (hr), vertical angle resolution (vr), and perfect resolution (pr), packed as:

 $10^4 * sr + 10^3 * rr + 10^2 * hr + 10 * vr + pr$.

 $[^]st$ Applicable if equal to 1; otherwise 0.

(This page blank)

| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|---|---------|-------------|-----------------------|-------|---|---------------|---|----------------------------|---------------------|
| 1 2 3 | TRF | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | RÍ | |
| 678 | (F10.3) | FLTARY(1) | * | * | 1st real parameter for Radar Type NRDR | RC(1,NRDR) | 6 7 8 9 10 11 12 13 14 15 | 2 READING ROUTINE | TRF |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (F10.3) | FLTARY(2) | * | * | 2nd real parameter | RC (2 ,NRDR) | 16 17 18 19 20 21 22 23 24 25 | RDRGEN | Real Parameters for |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (F10.3) | • | | | • | • | 30 31 32 33 34 35 | USING ROUTINE RDRGEN | Radar Type NRDR |
| 36 37 38 39 40 41 42 43 44 45 | (F10.3) | | | | (Continue as required for the number of floating point parameters specified for all simulation model options defined) | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 | REMARKS | |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | FLTARY (NF) | * | * | • | | 50 51 52 53 54 55 | e total num r all simul | |
| 8 | (F10.3) | | | | NFth real parameter | RC (NF ,NRDR) | 56 57 58 59 60 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | nt parameters required | PAGE 3 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | red | ω |

Amplification of Card Type TRF

The fields described below are for radar simulation model Options 1 through 4 which require up to eight floating point values. Other options, not yet defined, may require additional floating point values; these would be specified in additional card fields as required. The simulation model option for an individual radar set is selected in the Defense Generator.

| Card Columns | Description |
|--------------|--|
| 1-3 | The label "TRF" indicates that this card contains the floating point, or real parameters for the radar type being processed. |
| 6-15 | RC(1,NRDR). Lower bound of the vertical angle coverage for this radar type in degrees above (> 0) or below (< 0) the radar horizon. |
| 16-25 | RC(2,NRDR). Upper bound of the vertical angle coverage for this radar type in degrees* above (> 0) or below** (< 0) the radar horizon. |
| 26-35 | RC(3,NRDR). Receiver horizontal 3db beamwidth in degrees. |
| 36-45 | RC(4,NRDR). Receiver vertical 3db beamwidth in degrees*. This parameter is ignored if the antenna pattern specified is other than a pencil beam. |
| 46-55 | RC(5,NRDR). Peak power level in the transmitted pulse in megawatts. |

^{*} Angular values are converted and stored in units of radians.

^{**} Coverage below the horizon applies to targets at ranges less than R (the range to the horizon for a zero altitude target) which may have negative elevation angles but are visible nevertheless.

Amplification of Card Type TRF (Concluded)

| Card Columns | Description |
|--------------|--|
| 56-65 | RC(6,NRDR). Transmitted pulse length in microseconds. |
| 66-75 | RC(7,NRDR). Received pulse length, after compression, in microseconds. (Differs from the transmitted pulse length by the pulse compression ratio). |
| Second card | |
| 1-3 | The label "TRF". |
| 6-15 | RC(8,NRDR). The speed (doppler) resolution parameter in kft/sec. |

| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|---------|-----------------------|---------|--|-----------------------------------|---|------------------|--------------------------------|
| 1 2 3 | T G | | | | Label | n/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20н) | (ACARD) | (Alpha) | | Guidance Channel Constraint Group Type name | GCGTNM (I,NGCG), I=1,N2OBCD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | READING TYPGEN | TG PURPOSE Guidance Channel Co |
| 26 | (51) | NGCG | 1 to NGCTMX | integer | Guidance Channel Constraint Group Type number | N/A | 26 27 28 29 30 | | Constraint Group Type Header |
| 27 28 29 30 31 32 33 34 35 36 | (15) | NC | 1 to 31 | integer | Total number of Guidance Channels associated with this Constraint Group Type | NGCTYP (NGCG) ^C | 31 32 33 34 35 | GCGEN | Group Typ |
| 36 37 38 39 40 | (15) | TN | 0 to 7 | integer | Number of Inflight Transitions associated with this Constraint Group Type | NGCTYP (NGCG) | 36 37 38 39 40 | | e Header |
| 41 42 43 44 46 | (15) | NR | 1 to 8 | integer | Number of Constraint Equations associated with this Constraint Group Type | ngctyp (ngcg) ^e | 41 42 43 44 45 | REMARKS | |
| 37 38 39 40 41 42 43 44 46 46 47 48 49 50 51 52 53 54 55 | (15) | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 54 55 | (15) | | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 60 | (15) | | | | | | 56 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 61 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | : 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | 4 |

Amplification of Card Type TG

Each missile launcher has associated with it a guidance channel group of one or more guidance channels, or information processors. Many guidance channel groups within a task force may follow the same laws or rules governing multiple, simultaneous engagements, and a constraint group type is simply a collection of parameters describing the behavior of a family, or group, of guidance channels. The form and application of the constraint expressions are as follows.

For any missile assignment, define the state of the assignment at time t to be the number of inflight transitions having been passed through at that time. Thus, the assignment is in state 0 at launch time and state NT (the number of inflight transitions) at intercept time. Consider a column vector S(t) having components $s_i(t)$, where $s_i(t)$ is the total number of assignments in state i at time t being serviced by the guidance channel group under consideration. The guidance-channel constraint may be expressed as:

$A S(t) \le n(t)C$ for any t

where

- A = an NR by NT+1 array of coefficients
- S(t) = the NT+1 by 1 column vector of assignments at time t
- C = an NR by 1 column vector of constraints.

Amplification of Card Type TG (Concluded)

A new missile engagement will be undertaken only if the inequality above would be satisfied throughout the anticipated time of flight of the assignment under consideration.

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "TG" indicates that this card is a header for a guidance channel constraint group type. |
| 6-25 | 20-character field which may be used to assign a name to the guidance channel constraint group type being defined. |
| 26-30 | Identification number for this guidance-channel constraint group type. |
| 31-35 | Total number of guidance channels associated with this constraint-group type. |
| 36-40 | Number of inflight transitions, NT, associated with this constraint-group type. This value plus one corresponds to the number of entries on Card Type TGP and to the column dimension of the array A on Card Type TGA. |
| 41-45 | Number of constraint equations, NR, associated with this constraint group type. This value corresponds to the number of entries on Card Type TGC and to the row dimension of the array A on Card Type TGA. |

| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|------------------|-----------------------|---------|---|------------------------------|---|----------|--------------------------------|
| 11 2 3 | TGP | | | | Label | N/A | 1 2 3 | NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | n/A | 4 5 | EAT A | |
| 6 7 8 9 10 | (15) | INTARY (1) | 0 to 100 | percent | P ₁ , percent of total flight time at which 1st Constraint Transition occurs | KGCPCa (NGCG) | 6 7 8 9 10 | 3 | TGP |
| 11 12 13 14 15 | (15) | INTARY (2) | P ₁ to 100 | percent | P ₂ 2nd Transition | kgcpc _b (ngcg) | 11 12 13 14 15 | READING | PURPOSE |
| 16 17 18 19 20 | (15) | INTARY (3) | P ₂ to 100 | percent | P ₃ 3rd Transition | KGCPC _C (NGCG) | 16 17 18 19 20 | GCGEN | Transitio |
| 21 22 23 24 25 | (15) | • | | • • • | • | : | 21 22 23 24 25 | | n Points |
| 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (15) | INTARY (NT) | P NT-1 to 100 | percent | P _{NT} NTth Transition | KGCPC* | 26 27 28 29 30 | BOUTINE | Transition Points for G.C.C.G. |
| 31 32 33 34 35 | (15) | INTARY (NT+1) | 100 only | percent | P NT+1 Final Transition | KGCPC* | ाध | GCGEN | G. Type NGCG |
| 36 37 38 39 40 | (15) | | | | | | 32 33 34 35 36 37 38 39 40 | | čć |
| 41 42 43 44 45 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 6 47 48 49 505 | (15) | | | | | | 46 47 48 49 50 | | |
| 1 52 53 54 55 5 | (15) | | | | | | 51 52 53 54 55 56 | | |
| 6 57 58 59 606 | (15) | | | | | | ψ, | TN | |
| 162 63 64 65 6 | (15) | | | | | | 1 62 63 64 65 | T < 7 | |
| 667 68 69 707 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 72 73 74 | (15) | | | | | | 71727374 | | 22 |
| 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | 0F 4 |

Amplification of Card Type TGP

Each element of the column vector P on this card corresponds to a percentage of total flight time of a missile assignment (i.e., the time from launch to predicted intercept). Each such percentage multiplied by the total flight time determines a point in time during the flight of a missile at which transition is made from one guidance state to the next. The components of this vector are nondecreasing (i.e., $P_{i+1} \geq P_i$), and the final transition percentage is always 100. Thus, if zero (0) transitions are specified on Card Type TG, a single value of 100 would be entered on Card Type TGP.

| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|--------|----------------|-----------------------|---------|--|------------------------------|--|--------------------|-----------------------|
| 1 2 3 | TGC | | | | Label | n/A | 12345 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | ₽Ţ | |
| 6 7 8 9 10 | (15) | INTARY (1) | 0 to 255 | integer | ${f C}_1$, 1st Component of the Constraint Vector C for Constraint Group Type NGCG | KGCPC ₁ (NGCG) | 6 7 8 9 10 | 3 | TGC |
| 11 12 13 14 15 | (15) | INTARY (2) | 0 to 255 | integer | C ₂ , 2nd Component | kgcpc _j (ngcg) | ᇙ | READING ROUTINE | PURPOSE |
| 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | INTARY (3) | 0 to 255 | integer | C ₃ , 3rd Component | KGCPC k (NGCG) | 16 17 18 19 20 | GCGEN | Constraint Vector, C, |
| 21 22 23 24 25 | (15) | • | | | • | • | 21 22 23 24 25 | | t Vector, |
| 26 27 28 29 3031 32 33 34 35 36 37 38 39 40 14 22 43 44 46 146 47 48 49 50 61 52 53 54 55 65 57 58 59 50 61 52 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 87 880 | (15) | INTARY (NR) | 0 to 255 | integer | C _{NR} , NRth Component | KGCPC _* (NGCG) | 26 27 28 29 30 31 32 33 34 35 | ROUTINE | C, for G.C.C.G. |
| 31 32 33 34 36 | (15) | | | | | | 31 32 33 34 35 | GCGEN | C.C.G. Typ |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 4 | | Type NGCG |
| 11 42 43 44 45 | (15) | | | | | | 1 42 43 44 45 | REMARKS | |
| 16 47 48 49 50 | (15) | | | | | | 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 1 52 53 54 55 6 | (15) | | | | | | 1 52 53 64 55 5 | | |
| 6 57 58 59 606 | (15) | | | | | | 6 57 58 59 60 6 | NR | |
| 1 62 63 64 65 6 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 (| R < 8 | |
| 6 67 68 69 707 | (15) | | | | | | 36 67 68 69 70 | | PAGE |
| 1 72 73 74 75 | (15) | | | | | | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | s Q |
| 76 77 78 7980 | (XS) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 4 |

Amplification of Card Type TGC

The column vector, C, defined on this card is the principal element on the right-hand side of the guidance channel constraint group inequality expression discussed with Card Type TG.

| | FORMAT | LOCAL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION | | | |
|--|--------|--------------------|-----------------------|---------|--|-----------------------------|---|------------------|--------------|
| 1 2 3 | T GA | | | | Label | N/A | 1 2 3 4 5 | FORMAT NUMBER | CARD |
| 4.5 | (12) | | | | (Unused Integer) | n/A | 4 5 | ∺ή | |
| 6 | | INTARY (1) | 0 to 63 | integer | A ₁₁ , Row 1, Column 1 Entry in the Constraint Array A for Constraint Group Type NGCG | KGCA _a (NGCG) | 6 7 8 9 10 | သ | TGA |
| 11 12 13 14 15 | (15) | INTARY (2) | 0 to 63 | integer | A ₁₂ | KGCA _b (NGCG) | 15 | READING | PURPOSE |
| 16 17 18 19 20 | (15) | INTARY (3) | 0 to 63 | integer | A ₁₃ | KGCA _C (NGCG) | 16 17 18 19 20 21 | GCGEN | Constraint |
| 21 22 23 24 25 | (15) | • • • | | | • | • | 22 23 24 25 | | t Array, A, |
| 7 8 9 10 11 1 2 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 28 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 48 50 51 52 53 54 55 | (15) | INTARY (NT+1) | 0 to 63 | integer | ^A 1 ,NT+1 | KGCA* (NGCG) | 뾩 | USING ROUTINE | , for G.C.C. |
| 31 32 33 34 35 | (15) | INTARY (NT+2) | 0 to 63 | integer | A ₂₁ | KGCA _* (NGCG) | 3132333435 | GCGEN | G. |
| 36 37 38 39 40 | (15) | : | | | • | • | 36 37 38 39 40 | | Type NGCG |
| 41 42 43 44 45 | (15) | | | | (Continue as required on up to four additional cards) | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | • | | | • | • | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | INTARY (NR*(NT+1)) | 0 to 63 | | A _{NR} ,NT+1 | KGCA _* (NGCG) | 51 52 53 54 55 54 | | |
| 56 57 58 59 50 | (15) | | | | | | Ų, | NR* (NT+1) | |
| 6162636465 | (15) | | i. | | | | 51 62 63 64 65 | T+1) < 64 | |
| 66 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 56 57 58 59 50 61 62 63 64 85 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | . 4 OF |
| 76 77 78 7980 | (5x) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | 4 |

Amplification of Card Type TGA

The array, A, defined on the TGA card(s) corresponds to the coefficient array on the left-hand side of the guidance channel constraint group inequality expression discussed with Card Type TG.

| ſ | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | |
|--|--------|-------|-----------------------|---------|---|-----------------------------|---|------------------------|
| 1 2 3 | TE | | | | Label | N/A | NUMB 1 2 3 | CARD NAME FORMAT |
| 5 | (12) | | | Γ | (Unused Integer) | N/A | \$ B | 4 |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 Be 77 28 29 30 51 32 33 34 35 Be 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 65 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 P6 77 78 78 80 | (20Н) | | | | (Not Used) | | JROUTINE 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | ECM Loading Group |
| 26 27 28 29 30 | (15) | NG | 1 to NECMAX | integer | ECM Loading Group index value | N/A | ROUTINE 26 27 28 29 30 | USING |
| 31 32 33 34 35 | (15) | | 0 or 1 only | integer | Communications Band jamming indicator (0 - no, 1 - yes) | NECMGP _C (NG) | 31 32 33 34 35 36 37 38 39 40 | RCMCEN |
| 36 37 38 39 40 | (15) | | 0 to 1023 | w/mHz | P-Band power density | necmgp _d (ng) | 36 37 38 39 40 | |
| 41 42 43 44 45 | (15) | | 0 to 1023 | w/mHz | L-Band power density | necmgp _d (ng) | 41 42 43 44 45 46 47 48 49 50 | REMARKS |
| 46 47 48 49 50 | (15) | | 0 to 1023 | w/mHz | S-Band power density | NECMGP _f (NG) | 46 47 48 49 50 | |
| 51 52 53 54 55 | (15) | | 0 to 1023 | w/mHz | C-Band power density | NECMGP g (NG) | 51 52 53 54 55 | |
| 56 57 58 59 50 | (15) | | 0 to 1023 | w/mHz | X-Band power density | NECMGP h (NG) | 56 57 58 59 60 | |
| 61 62 63 64 65 | (51) | | | | | , | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | |
| 66 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | PAGE |
| 71 72 73 74 75 | (15) | | | | | | 7172737475 | 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 7980 | 1 |

Amplification of Card Type TE

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "TE" indicates that this is an ECM Loading Group card. |
| 26-30 | The identification number of the ECM Loading Group data that follows. It may be used as a reference number when generating targets (aircraft and missiles). |
| 31-35 | Communications band jamming indicator where 1 indicates that this is a jamming group and 0 (or blank) that it is not. |
| 36-40 | P-Band power density given in w/mHz. |
| 41-45 | L-Band power density given in w/mHz. |
| 46-50 | S-Band power density given in w/mHz. |
| 51-55 | C-Band power density given in w/mHz. |
| 56-60 | X-Band power density given in w/mHz . |

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|----------|-------|-----------------------|---------|--|-----------------------------|--|------------------|---------------------------------------|
| 1 2 3 | тс | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| - | (12) | | | | (Unused Integer) | N/A | 5 | ERT | |
| 6 7 8 | | | | | | | 6 7 8 9 1011 | 1 R | TC PI |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 28 27 28 28 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 68 | (20H) | | | | (Not Used) | | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | READING TYPGEN | PURPOSE Cross Section Group Header |
| 26 27 28 29 30 | (15) | NG | 1 to | integer | Cross Section Group index value | n/a | 26 27 28 29 30 | USING ROUTINE | Header C |
| 31 32 33 34 36 | (15) | Ж | 1,2, or 3 only | integer | Option number | NCSGRP _C (NG) | 27 28 29 30 31 32 33 34 35 36 37 38 39 40 | CSGEN | Card |
| 36 37 38 39 40 | (15) | NI | 1 to 7 only | integer | Number of rows in Cross Section Data to follow | ncsgrp _d (ng) | | | |
| 41 42 43 44 46 | (15) | LN | 1 to 7 only | integer | Number of columns in Cross Section Data to follow | NCSGRP _e (NG) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | integer | Cross Section Model Number (Scintillation Group) | NCSGRP _f (NG) | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 60 | (15) | | | | | | 56 57 58 59 60 | | |
| 51 62 63 64 85 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 1 72 73 | (15) | | | | | | 717273 | | ۳ |
| 74 75 76 77 | \dashv | | | | (0,000,000,000,000,000,000,000,000,000, | N7/4 | 74 75 76 77 | | OF 2 |
| 78 79 80 | (5 X) | | | | (Sequence Field) | N/A | 78 79 80 | | |

Amplification of Card Type TC

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "TC" indicates that this is a cross-section group-header card. |
| 26-30 | The identification number, NG, of the cross section group data that follow. This value may be used as a reference number in describing a target type on Card Type TT. |
| 31-35 | Option number for radar cross_section data. The available options are: |
| | Option 1: $\sigma(I,M) = A(I,1,M)$ |
| · | Option 2: $\sigma(I, \Phi, M) = \sum_{j=1}^{NJ} \left\{ A(I, j, M) \Phi^{j-1} \right\}$ |
| | Option 3: $\sigma(\Phi_H, \Phi_V, M) = \sum_{i=1}^{NI} \sum_{j=1}^{NJ} A(i,j,M) \Phi_H^{i-1} \Phi_V^{j-1}$ |
| where | |
| σ | = the radar cross section value computed for the target being considered |
| I | = the radar frequency band index |
| М | = the cross section group to which the target belongs (=NG) |
| A | = the cross section data array |
| Φ | = the solid aspect angle of the target with respect to the radar position |

Amplification of Card Type TC (Concluded)

Card Columns

Description

 $\Phi_{\mathbf{H}}$ = the horizontal aspect angle

 $\Phi_{\mathbf{V}}$ = the vertical aspect angle.

Note that the cross section value computed with Option 3 is independent of the radar frequency band.

- 36-40 Number of rows, NI, in cross-section data to be specified on Card Type TCD.
- Number of columns, NJ, in cross-section data to be specified on Card Type TCD. If Option 1 is given on columns 31-35 of this card, the value of this field is assumed to be 1.
- 46-50 Cross-section model number (scintillation group).

| ſ | ē | 55 | ≨ R | ş | | | 1 | | |
|---|---------|-------------|-----------------------|-------|---|----------------------|--|-------------|-----------------------------|
| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | TCD | | | | Label | N/A | 1 2 3 | FORMAT | CARD NAME |
| 4 5 | (12) | | | , | (Unused Integer) | N/A | 101 | Ā | |
| 6 7 8 9 10 11 12 13 14 15 | (F10.3) | FLTARY(1) | (Any Real Number) | | Row 1, Column 1 Entry for Cross Section Group NG | CSDATA (1,1,NG) | 7 8 9 | 2 READING | TCD PURPOSE |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (F10.3) | FLTARY(2) | | | Row 2, Column 1 Entry | CSDATA (2,1,NG) | 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | CSGEN | Reflection Data fo |
| 26 27 28 29 30 31 32 33 34 35 | (F10.3) | • | , | | • | ; | | USING CSCRN | for Cross Section Group, NG |
| 36 37 38 39 40 41 42 43 44 45 | (F10.3) | FLTARY (NI) | | | Row NI, Column l Entry | CSDATA (NI,1,NG) | HOUTINE 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | REMARKS | oup, NG |
| 46 47 48 49 50 51 52 53 34 55 | (F10.3) | • | | | • | • | 46 47 48 49 50 51 52 53 54 55 | | |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 34 55 56 57 58 59 50 51 62 63 64 68 66 7 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | | (Continue as required on up to six additional cards) | | | ١ | |
| 36 67 68 69 70 71 72 73 74 75 | (F10.3) | FLTARY(NUM) | | | Row NI, Column NJ Entry | CSDATA (NI,NJ,NG) | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 2 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 2 |

Amplification of Card Type TCD

Repeat as many cards of this type (up to 7 cards) as is necessary to describe the cross-section data array. Each card must have the letters TCD in columns 1-3.

If Option 1 is selected on Card Type TC, only one card is necessary to list the single column of cross section data for this group.

| ſ | FORMAT | LABEL | OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|--------|---------|----------------|---------|---|----------------------------------|---|------------------|----------------------------------|
| 11 2 3 | T S | | | T | Label | N/A | 1 2 3 4 5 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | Π | (Unused Integer) | n/a | 5 | | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20н) | (ACARD) | (Alpha) | | Ship Type name | SHPINM (I,NST), I=1,N2OBCD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | 1 READING TYPGEN | TS PURPOSE Ship Type Header Card |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 40 46 47 48 49 50 61 52 53 34 55 66 57 58 59 60 61 62 63 64 68 66 67 68 69 70 71 72 73 74 76 76 77 78 79 80 | (15) | NST | 1 to NSTMAX | integer | Ship Type index value | N/A | | ROUTINE | rd |
| 31 32 33 34 35 | (15) | NR | 0 to 7 | integer | Number of Scanning Radar Sets on Ship Type NST | NSHPT _C (NST) | 3132333435 | SHPGEN | |
| 36 37 38 39 40 | (15) | NG | 0 to 7 | integer | Number of Guidance Channel Groups on Ship Type NST | NPSHPT _d (NST) | 36 37 38 39 40 41 42 43 44 45 | | |
| 41 42 43 44 45 | (15) | NC | 0 to 63 | integer | Total number of Guidance Channels on Ship Type NST | NPSHPTe | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | NL | 0 to 15 | integer | Total number of Missile Launchers on Ship Type NST | NPSHPT _f (NST) | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | NOPS | 0 to 6 | integer | Number of Tracking Operators on Ship Type NST (for TDHS version only) | | 51 52 53 54 56 | | |
| 56 57 58 59 <u>60</u> | (15) | | | | | | 56 57 58 59 60 | | |
| 162 63 64 65 6 | (15) | | | | | | 61 62 63 64 65 | | |
| 6 67 68 69 707 | (I5) | | | | | | 6 67 58 59 60 61 62 63 64 65 66 67 68 69 70 | | PAGE |
| 1 72 73 74 75 | (15) | | | | · | | 71 72 73 74 75 | | 1 OF |
| 16 77 78 7980 | (5X) | | | | (Sequence Field) | | 76 77 78 79 80 | | 5 |

Amplification of Card Type TS

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "TS" indicates that this is a ship type header card. |
| 6-25 | 20-character field which may be used to assign a name to the ship type being defined. |
| 26-30 | The identification number for this ship type. |
| 31-35 | The number of scanning radar sets on this ship type. Each set will be assigned a radar type on Card Type TSR. |
| 36-40 | The number of guidance channel groups on this ship type. Data for each group are described on Card Type TSG. |
| 41-45 | The total number of guidance channels on this ship type. Each guidance channel group has associated with it one or more guidance channels. The sum of guidance channels over all such groups (see columns 36-40) must agree with the value of this field. |
| 46-50 | The total number of missile launchers on this ship type. Each guidance channel group services one or more launchers. The sum of launchers over all such groups must agree with the value of this field. |
| 51-55 | The number of tracking operators aboard this ship type. (for TDHS version only). |

| | FORMAT | LABEL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION |] | | |
|---|--------|----------------|-----------------------|---------|--|------------------------------|--|--------------------|----------------------------|
| 1 2 3 | TSR | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 5 | (12) | | | | (Unused Integer) | N/A | 5 | R-1 | ا ي |
| 9 | (15) | INTARY (1) | 1 to 31 | integer | Radar Type of the 1st Surveillance Radar Set for Ship Type NST | KRSHPT _a (NST) | 678910 | 3 | TSR |
| 11 12 13 14 15 | (15) | • | • | | • | | 5 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | INTARY (NR) | 1 to 31 | integer | Radar Type of the NRth Surveillance Radar Set for Ship Type NST | KRSHPT * (NST) | 16 17 18 19 20 21 | SHPGEN | earch Rad |
| 2 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (15) | | | | | | 22 23 24 25 | | Search Radar Configuration |
| 26 27 28 29 30 | (51) | | | | | · | 26 27 28 29 30 | USING ROUTINE | uration of |
| 31 32 33 34 35 | (15) | | | | | | 31 32 33 34 35 | SHPGEN | Ship Type NST |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 | | e NST |
| 41 42 43 44 45 | (15) | | | | | | 11 42 43 44 45 | REMARKS | ! |
| 46 47 48 49 50 | (15) | | | | | | 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| | (15) | | | | | | | | |
| 56 57 58 59 60 | (15) | | | | | | 56 57 58 59 60 61 62 63 64 65 | No TSR C | |
| \$1 62 63 64 65 G | (15) | | | | | | 1 62 63 64 65 | TSR Card if NR | |
| 6 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | = 0 | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 71 72 73 74 75 | | 2 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 4 |

Amplification of Card Type TSR

This card is necessary if the number of scanning radars specified on Card Type TS is nonzero. Columns 1-3 contain the letters TSR. Each scanning radar is assigned a radar type that has previously been defined by Card Types TR, TRI, and TRF. Up to seven scanning radar sets per ship type are allowable.

| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|---------|--|------------------------------|---|--------------------|--|
| 1 2 3 | TSG | | | | Label | n/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | 70 T | |
| 6 7 8 9 10 | (15) | | 1 to NRTMAX | integer | Tracking Radar Type for the 1st Guidance Channel Group for Ship Type NST | MNSHPT _a (NST) | 6 7 8 9 10 | 3 | TSG |
| 11 12 13 14 15 | (15) | | 1 to NGCTMX | integer | Guidance Channel Constraint Group Type for the 1st Guidance Channel Group for Ship Type NST | MNSHPT _b (NST) | 5 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | NLCHT | 1 to 3 only | integer | Number of Launcher Types serviced by the 1st Guidance Channel Group for Ship Type NST | MNSHPT C | 16 17 18 19 20 | SHPGEN | Weapons C |
| 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | | 1 to 15 only | integer | \mathtt{M}_{11} , the 1st Launcher Type serviced by the 1st G.C. Group | MNSHPT _d (NST) | 21 22 23 24 25 | | onfigurat |
| 26 27 28 29 30(2) 32 33 34 36 36 37 38 39 40(4) 42 43 44 46)46 47 48 49 50(6) 52 53 54 55(6) 57 58 59 50(6) 52 53 64 66(6) 68 69 70(7) 72 73 74 75 (6) 77 78 79 80 | (15) | | 1 to 7 only | integer | $ m N_{11}$, the number of launchers of Type $ m M_{11}$ serviced by the 1st G.C. Group | MNSHPT _e (NST) | 님 | ROUTINE | Weapons Configuration of Ship Type NST |
| 31 32 33 34 35 | (15) | • | • | | • | • | 31323334353637383940 | SHPGEN | p Type NS |
| 36 37 38 39 40 | (15) | | 1 to 15 only | | $^{ m M}_{ m NLCHT,1}$, the NLCHTth Launcher Type \dots | MNSHPT _* (NST) | 36 37 38 39 40 | | r |
| 41 42 43 44 45 | (15) | | 1 to 7 only | | $N_{ m NLCHT,1}$, the number of launchers of type $M_{ m NLCHT,1}$ | mnshpt _* (nst) | 41 42 43 44 45 46 47 48 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | 16 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | | | | (Only one Guidance Channel Group is described on each "TSG" card. Use additional cards of similar format as required to describe all 'NG" | | 49 50 51 52 53 54 55 | | |
| 56 57 58 59 60 | (15) | | | | Guidance Channel Groups specified on the "TS" card.) | | 6 57 58 59 60 | No TSG Ca | |
| 51 62 63 64 656 | (15) | | | | | | 31 62 63 64 65 | Card(s) if | |
| 6 67 68 69 707 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | NG = 0 | PAGE |
| 1 72 73 74 75 | (15) | | | | | | 71727374757 | | 3 OF |
| 16 77 78 7980 | (5x) | | | | (Sequence Field) | n/A | 6 77 78 79 80 | | 4 |

Amplification of Card Type TSG

There is one card of this type for each guidance-channel group (which means that no cards are necessary if there are 0 groups). The number of groups is given on Card Type TS. Each group has associated with it one or more guidance channels and services one or more launchers. When all TSG cards have been read for a ship type a check is made to see that the total number of guidance channels and launchers over all groups corresponds to the totals given on Card Type TS. If agreement is not found, the error indicator is turned on, a message is printed, and processing continues.

| Card Columns | Description |
|--------------|---|
| 1-3 | The label "TSG" indicates that this is a weapons configuration card for a guidance-channel group, IG, belonging to the ship type being processed, (NST). |
| 6-10 | Tracking radar type for guidance-channel group IG and ship type NST. This value refers to a data set defined by Card Types TR, TRI, and TRF. |
| 11-15 | The guidance channel constraint group type for guidance channel group IG and ship type NST. This value refers to a data set defined by Card Types TG, TGP, TGC, and TGA. Note that the guidance channel constraint group type determines the number of guidance channels for group IG (see Card Type TG). |
| 16-20 | The number of launcher types, NLCHT, serviced by guidance-channel group IG. |
| 21-25 | The 1st launcher type $M_{1,1G}$ serviced by guidance channel group IG. This value refers to a data set defined by Card Type TL. |
| 26-30 | The number of launchers N of type M serviced by guidance channel group IG. |

Amplification of Card Type TSG (Concluded)

| Card Columns | Description | | | | | | |
|--------------|--|--|--|--|--|--|--|
| 31-35 | Same as card columns 21-25 but for $M_{2,1G}$ if NLCHT ≥ 2 . | | | | | | |
| 36-40 | Same as card columns 26-30 but for $N_{2,IG}$ and $M_{2,IG}$ if NLCHT \geq 2. | | | | | | |
| 41-45 | Same as card columns 21-25 but for $M_{3,IG}$ if NLCHT = 3. | | | | | | |
| 46-50 | Same as card columns 26-30 but for $^{\rm N}_{\rm 3,IG}$ and $^{\rm M}_{\rm 3,IG}$ if NLCHT = 3. | | | | | | |

SHIP TYPE COMPONENT CARD

| | FORMAT | LABEL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION | | | |
|---|--------|-------|-----------------------|---------|--|-------------------------------------|---|--------------------|----------------|
| 1 2 3 | TSC | | | | Label | N/A | 1 2 3 | NUMBER | NAME |
| 5 | (12) | | | | (Unused Integer) | N/A | 5 | ΞĀ | |
| 6 7 8 9 10 1 | (15) | | | integer | Component ID No. | NSTCOM _a (NCOMP(1)+1) | 6 7 8 9 10 | S | TSC |
| 1 12 13 14 15 | (15) | | 1 to NCTMAX | integer | Component Type No. | NSTCOM _b (NCOMP(I)+1) | 11 12 13 14 15 | READING ROUTINE | |
| 16 17 18 19 20 | (15) | | | feet | X-Coordinate of Component Position | NSTCOM _e (NCOMP(I)+1) | 16 17 18 19 20 | SHPGEN | Component Data |
| 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | | | feet | Y-Coordinate of Component Position | NSTCOM _f (NCOMP(I)+1) | 21 22 23 24 2 | | |
| 26 27 28 29 30(31 32 33 34 35 36 37 38 39 40(47 42 43 44 46)46 47 48 49 50(51 52 53 54 55)56 57 58 59 50(61 62 63 64 68)66 67 68 69 70(71 72 73 74 75)6 77 78 79 80 | (15) | | | feet | Z-Coordinate of Component Position | NSTCOMg (NCOMP(I)+i) | 26 27 28 29 30 | HOUTINE : | for Ship Type |
| 31 32 33 34 35 | (15) | | 1 or 0 only | integer | Exterior (1)/Interior(0) to Ship Indicator | NSTCOM _h (NCOMP(I)+1) | 1 32 33 34 35 | SHPGEN | |
| 36 37 38 39 40 | (15) | | ≥ 0 | integer | Scenario Cost Index | NSTCOM _C (NCOMP(I)+1) | 36 37 38 39 40 | | |
| 41 42 43 44 46 | (21) | | 0,1,2 or 3 | integer | System Code (R=1, GC=2, L=3; 0 otherwise) | NSTCOM _i (NCOMP(I)+i) | 41 42 43 44 45 | REMARKS | |
| 16 47 48 49 50 | (15) | | | integer | System Type No. | NSTCOM _j (NCOMP(I)+i) | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 54 55 | (15) | | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 6Q | | |
| 51 62 63 64 65 e | (15) | | | | | | 61 62 63 64 65 | | |
| 6 67 68 69 7Q | (15) | | | | | | 86 67 68 69 70 | | PAGE |
| 71 72 73 74 75 | (15) | · | | | | | 6 57 58 59 60 61 62 63 64 65 86 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | E 4 OF |
| 76 77 78 79 80 | (5X) | | | | | | 76 77 78 79 80 | | 7 |

Amplification of Card Type TSC

One TSC card is required for each component associated with ship type NST. Usually one such card is defined for each of the NR radar systems, NC guidance channel systems, and NL launcher systems as specified on Card Type TS as well as for any other components desired to model the ship type. The sum of components taken over all ship types in a given replication may not exceed ICOMAX; the number associated with a particular ship type may range from zero to ICOMAX. Within each ship type, all type TSC cards must follow the last type TSG card and precede the type TSH card.

| Card Columns | Description |
|--------------|--|
| 1-3 | "TSC" label indicating this is a component card for ship type NST. |
| 6-10 | Component ID number, assigned by the user, which must be unique within ship type NST. |
| 11-15 | Component type number to be associated with this component, referring to the data set defined by cards of type TP. |
| 16-20 | x-coordinate of the component's position relative to the local ship type coordinate system (feet). |
| 21-25 | y-coordinate of the component's position relative to the local ship type coordinate system (feet). |
| 26-30 | z-coordinate of the component's position relative to the local ship type coordinate system (feet). |
| 31-35 | Binary flag indicating component is exterior (1) or interior (0) to the ship's hull. |

Amplification of Card Type TSC continued

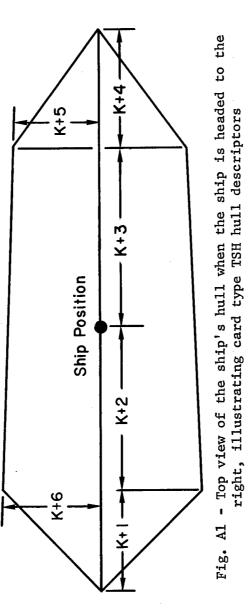
| Card Columns | Description |
|--------------|--|
| 36-40 | Scenario cost index, indicating the component's value to the task force overall. |
| 41-45 | System code, indicating that this component is a radar (1), guidance channel (2), launcher (3), or other type of component (0 or blank). |
| 46-50 | System type number, giving radar type number, guidance channel type number, or launcher type number, if system code above is 1, 2, or 3 respectively; field is 0 or blank otherwise. |

| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|-------|----------------------------------|------------------------|--|--------------------|---------------|
| 1 2 3 | TSH | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | 1 | HST |
| 6 7 8 9 10 | (15) | | | feet | epth of keel NSPGØ(I)) | | 6 7 8 9 10 | 3 | |
| 11 12 13 14 15 16 | (15) | | | feet | Hull Descriptor | NSPGØ (NNSPGØ(I)+1) | 11 12 13 14 15 | READING ROUTINE | PURPOSE Sh |
| 6 17 18 19 20 | (15) | | | feet | Hull Descriptor NSPGØ (NNSPGØ(I) | | 16 17 18 19 20 | SHPGEN | Ship Hull G |
| 17 18 19 20 21 22 23 24 25 | (15) | | | feet | Hull Descriptor | NSPGØ (NNSPGØ(I)+3) | 21 22 23 24 25 | | Geometry Card |
| 26 27 28 29 30 | (15) | | | feet | Hull Descriptor | nspgø (nnspgø(I)+4) | 6 27 28 29 30 | HOUTINE | rd for Ship |
| 27 28 29 30 31 32 33 34 36 | (15) | | | feet | Hull Descriptor | NSPGØ (NNSPGØ(I)+5) | 31 32 33 34 35 | | tp Type NST |
| 36 37 38 39 40 | (15) | | | feet | Hull Descriptor | NSPGØ (NNSPGØ(I)+6) | 6 37 38 39 40 | | T |
| 41 42 43 44 45 | (15) | | | feet | Height of main deck above water | NSPGØ (NNSPGØ(I)+7) | 36 37 38 39 40 41 42 43 44 45 46 47 48 | REMARKS | |
| 37 38 39 40 41 42 43 44 46 48 47 48 49 50 51 52 53 54 55 | (15) | | | | | | 16 47 48 49 50 | | |
| | (15) | | | | | | 49 50 51 52 53 54 55 5 | • | |
| 56 57 58 59 50 | (15) | | | | | | 6 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 51 62 63 64 65 | | |
| 86 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 7 6 77 78 79 80 | (15) | | | | , | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | : 5 OF |
| 76 77 78 7980 | (5X) | | | | , | | 76 77 78 79 80 | | 7 |

Amplification of Card Type TSH

Card Type TSH describes the geometry of the ship's hull. Exactly one TSH card is required within each ship type data set, and it must follow the last type TSC card, if any, and precede the first type TSS card, if any.

| Card Columns | Description |
|--------------|--|
| 1-3 | "TSH" label indicating this is a ship hull-geometry card for ship type NST. |
| 6-10 | Depth of keel in feet. |
| | The following six entries are hull descriptors, representing distances in feet as illustrated on the following page in Figure A-1: |
| 11-15 | Hull descriptor K+1, |
| 16-20 | Hull descriptor K+2, |
| 21-25 | Hull descriptor K+3, |
| 26-30 | Hull descriptor K+4, |
| 31-35 | Hull descriptor K+5, |
| 36-40 | Hull descriptor K+6, |
| 41-45 | Height of main deck above water, expressed in feet. |



SHIP TYPE RECTANGULAR SOLID GEOMETRY CARD

| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|-------|-----------------------|-------|-------------------------|-------------------------|---|------------------|--|
| 1 2 3 | TSS | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 4.5 | (12) | | | | (Unused Integer) | N/A | 5 | ER | TSS |
| 6 7 | (15) | | | feet | Position - x coordinate | NSPGØ (NNSPGØ(I)+8) | 6 1 8 9 10 | 3 | SS |
| 11 12 13 14 15 | (15) | | | feet | Position - y coordinate | NSPGØ (NNSPGØ(I)+9) | 11 12 13 14 15 16 17 18 19 20 | READING S | PURPOSE Sh |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | | | feet | Position - z coordinate | NSPGØ (NNSPGØ(I)+10) | 16 17 18 19 20 | SHPGEN | ip Rectans |
| 21 22 23 24 25 | (21) | | | feet | Length | NSPGØ (NNSPGØ(I)+11) | 21 22 23 24 25 | | gular Soli |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 46 48 47 48 49 50 61 52 53 54 55 | (15) | | | feet | Width | NSPGØ (NNSPGØ(I)+12) | | SING OUT INE | Ship Rectangular Solid Geometry Card for Ship Type NST |
|) 32 33 34 36 | (15) | | | feet | Height | NSPGØ (NNSPGØ(I)+13) | 30 31 32 33 34 35 | SHPGEN | Card for |
| 36 37 38 39 40 | (15) | | | | | | 6 37 38 39 40 4 | | Ship Type |
| 41 42 43 44 46 | (15) | | | | | | 1 42 43 44 45 | REMARKS | NST |
| 48 49 50 | (15) | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| | (15) | | | | | | | | |
| 56 57 58 59 50 | (15) | | | | | | 6 57 58 59 60 | | |
| 51 62 63 64 66 | (15) | | | | | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | |
| ¥6 67 68 69 70 | (I.5) | | | | | | 66 67 68 69 70 | | PAGE |
| 56 57 58 59 50 61 62 63 64 85 86 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 7172737475 | | 6 OF |
| 76 77 78 79 80 | (5X) | | | | | | 76 77 78 79 80 | | 7 |

Amplification of Card Type TSS

Card Type TSS describes the size and location of a rectangular solid positioned on the ship's deck. One TSS card is required for each rectangular solid used to model the superstructure of the ship. All type TSS cards for a given ship type, if any, follow the type TSH card and precede the type TSX card.

| Card Columns | <u>Description</u> |
|--------------|--|
| 1-3 | "TSS" label indicating this is a ship-rectangular-solid-geometry card for ship type NST. |
| 6-10 | x-coordinate of the rectangular solid's location relative to the local ship type coordinate system (feet). |
| 11-15 | y-coordinate of the rectangular solid's location relative to the local ship type coordinate system (feet). |
| 16-20 | z-coordinate of the rectangular solid's location relative to the local ship type coordinate system (feet). |
| 21-25 | Length of the rectangular solid, expressed in feet. |
| 26-30 | Width of the rectangular solid, expressed in feet. |
| 31-35 | Height of the rectangular solid, expressed in feet. |
| | |

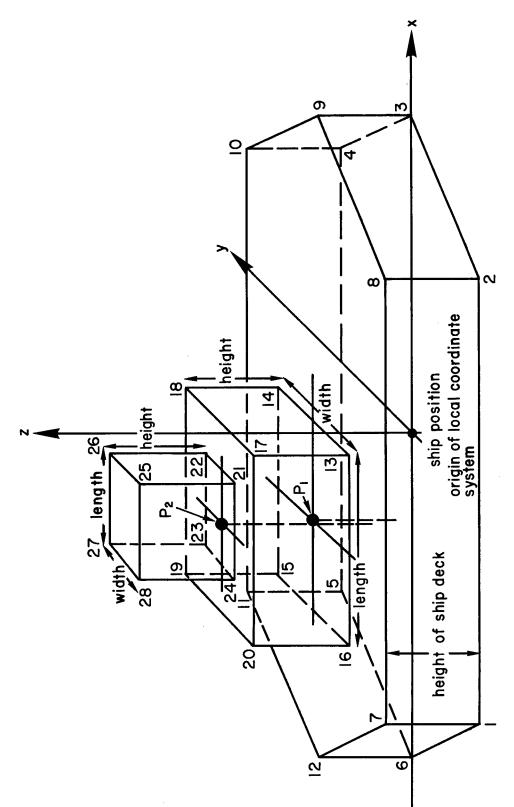


Fig. A2 - Illustration of ship in the rectangular-solid configuration

Example of Ship in Rectangular Solid Configuration

Figure A-2 illustrates a hypothetical ship in rectangular solids configuration. The main deck is represented by the solid outlined by indices 1 through 12, with the water line indicated by indices 1 through 6. The superstructure of the ship is described by two rectangular solids, the larger by indices 13 through 20 and the smaller by indices 21 through 28.

The geometrical description of this ship would consist of one card of type TSH followed by two cards of type TSS. The parameters describing the hull and main deck - the hull descriptors as illustrated in Figure A-1, the depth of the keel, and the height of the main deck - would appear on the type TSH card. Each type TSS card would contain a description of one of the two rectangular solids, including its position (P₁ or P₂) expressed in terms of the local ship Cartesian coordinate system and its length, width, and height as illustrated in Figure A-2.

| | FORMAT | LOCAL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|---------|---|---------------------------|--|--------------------|--|
| 1 2 3 | TST | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | R A | |
| 67 | (15) | | 1-NR | integer | The local radar number to which the Track Supervisor is assigned | KTSHPT _a (NST) | 6 7 8 9 10 | 3 | TST* |
| 11 12 13 14 15 | (15) | | 0-31 | integer | 0 or blank if full scope, n otherwise; $n=1, 2, \ldots$, where scope limit = $(1/2)^n$ times full scope | KTSHPT _b (NST) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | 1-NR | integer | The local radar number to which the first tracking operator is assigned. Add 10 to the number if the operator is in automatic offset mode | KTSHPT _c (NST) | 16 17 18 19 20 | SHPGEN | Track Sup |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 | (15) | | 0-31 | integer | Same as columns 11-15 except for the first tracking operator | KTSHPT _d (NST) | 21 22 23 24 25 | | ervisor and ' |
| 26 27 28 29 30 | | | | | • | | 18 | USING ROUTINE | Tracking Ope |
| 31 32 33 34 35 | | | | | Repeat until radar and scope limit assignments have been made for each tracking operator | | 31 32 33 34 35 | SHPGEN | erator Radaı |
| 36 37 38 39 40 41 42 43 44 46 46 47 48 49 50 51 52 53 34 55 56 57 58 59 50 61 62 63 64 66 66 67 68 69 70 71 72 73 74 75 p6 77 78 79 80 | | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | REMARKS | Track Supervisor and Tracking Operator Radar Assignments for Ship Type NST |
| 72 73 74 75 71 | | _ | | | | | 17273747570 | | 3 OF |
| 6 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 6 77 78 79 80 | | 5 |

Amplification of Card Type TST

This card appears only in the TDHS version of the model, where it follows Card Type TSR. This card is necessary if the number of scanning radars specified on Card Type TS is nonzero. Columns 1-3 contain the letters TST. The first entry gives the local radar number (1 - NR) to which the Track Supervisor is assigned, and the second entry gives the factor (power of 2) to be applied to the scope limit of the radar. Then for each tracking operator associated with this ship type the remaining entries give the local radar assignment and the scope limit factor. If the operator is in automatic offset mode, add 10 to the local radar number and enter this value for the operator.

| | - | r | | | | | 7 | | |
|--|--------|--------|-----------------------|---------|---|------------------------------|--|--------------------|---|
| | FORMAT | LABEL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | TSV | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | ([2] | | | | (Unused Integer) | N/A | 4 5 | 33.4 | ایا |
| 678 | (15) | | 0 to 630 | feet | $ ho_1$, radial distance to the 1st Component Group on Ship Type NST | NVSHPT _a (NST) | 6 7 8 9 10 | 3 | TSV . |
| 9 10 11 12 13 14 15 16 | (15) | | 0 to 360 | degrees | $	heta_1$, bearing to the 1st Component Group CW from the bow | NVSHPT _b (NST) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | 0 to 63 | feet | Z_1 , height of the 1st Component Group above the ship z coordinate | NVSHPT _c (NST) | 16 17 18 19 20 | SHPGEN | Component |
| 17 18 19 20 21 22 23 24 25 | (51) | | 0 to 63 | integer | V ₁ , vulnerability factor for the 1st Component Group | NVSHPT _d | 21 22 23 24 25 | | Component Vulnerabilities for Ship Type NST |
| 8 | (15) | NI_1 | 0 to 63 | integer | n ₁ , number of components (colocated) in the 1st Component Group | NVSHPT _e (NST) | ١ŏ | ROUTINE . | ies for Ship |
| 27 28 29 30 31 32 33 34 35 | (15) | | 0 to 630 | feet | $ ho_2$ | NVSHPT _f (NST) | 31 32 33 34 35 | SHPGEN | Type NST |
| 36 37 38 39 40 | (15) | | 0 to 360 | degrees | θ_2 | NVSHPT _g (NST) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (21) | | 0 to 63 | feet | z_2 | NVSHPT _h (NST) | 41 42 43 44 45 | | |
| 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 | (51) | | 0 to 63 | integer | v ₂ | NVSHPT _i (NST) | 46 47 48 49 50 | TSV | |
| 55 | (15) | NI_2 | 0 to 63 | integer | n_2 | NVSHPT _j (NST) | 51 52 53 54 55 | d(s) if NR | |
| 56 57 58 59 60 | (15) | • | : | | : | • | 56 57 58 59 60 61 62 63 64 65 | =NL=NC | |
| 6162636466 | (15) | | | | [Continue with up to a total of ten ρ, θ, z, v, n 5-tuples (1 or 2 such 5-tuples per TSV card) for Ship Type NST, such that Σ $n_i \geqslant NR+NC+NL$] | | | | |
| 66 67 68 69 70 | (51) | | | | | | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 71 72 73 74 757 | | 4 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/a | 6 77 78 79 80 | | 4 |

Amplification of Card Type TSV

This card temporarily replaces the TSC, TSH, and TSS card types in the TDHS version of the model. At the present time, damage assessment in the TDHS version is much simplified from the parent model. Given an IMPACT event, damage probabilities are calculated directly from the warhead size of the impacting target, the relative vulnerability of each shipboard component (limited here to radars, guidance channels, and missile launchers), and the distance of each such component from the detonation point of the impacting weapon. Monte Carlo evaluations are then made to determine the survival of individual components. Once a component is disabled, it remains so for the duration of the game.

Each ship type has associated with it NR radars, NC guidance channels, and NL launchers. These values are specified on Card Type TS. If the sum of these components, NRLC, is 0 (NR+NC+NL=0) then no cards of this type are required. If the sum is non-zero, the position and vulnerability factor of each component is described on this card type. The data are first listed for all radars, followed by guidance channels, and finally by launchers.

Components that are colocated form a component group. Each component group is described by a 5-tuple ρ_i , θ_i , Z_i , V_i , n_i where n_i represents the number of components in group i at position ρ_i , θ_i , Z_i and with vulnerability factor V_i . Two 5-tuples may be specified on one card, and up to 10 5-tuples are allowed for describing all components. The sum of n_i over all 5-tuples given must be equal to NRLC.

| Card Columns | Description |
|--------------|--|
| 1-3 | The label "TSV" indicates that this is a component vulnerability card for ship type NST. |
| 6-10 | ρ_i , radial distance from the center of ship type NST to the ith component group. |
| 11-15 | $\theta_{\it i}$, bearing (clockwise from the bow) to the ith component group. |
| 16-20 | Z_i , height of the ith component above the ship Z-coordinate. |
| 21-25 | $V_{\it i}$, vulnerability factor for the ith component group. |
| 26-30 | n_i , the number of colocated components in the ith component group. |

Continue as required with a second 5-tuple in columns 31-55 and/or with additional 5-tuple on up to nine additional TSV cards.

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|-------|------------------|-------------|---|--------------------|------------------|
| 1 2 3 | TSX | " | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 4 5 | ([2) | | | | (Unused Integer) | N/A | 4 5 | RAT | 1 |
| 6 7 8 9 10 | (15) | | | | | | 6 7 8 9 10 | 3 | TSX |
| 11 12 13 14 15 | (15) | | | | | | 10 11 12 13 14 15 16 17 18 19 20 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | | | | | 16 17 18 19 20 | SHPGEN | Termination Card |
| 21 22 23 24 25 | (15) | | | | | | 21 22 23 24 25 | | |
| 26 27 28 29 30 | (15) | | | | | | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | HOUTINE | for Ship Type |
| 31 32 33 34 35 | (15) | | | | | | 31 32 33 34 35 | SHPGEN | e NST |
| 36 37 38 39 40 | (51) | | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | | | | | 11 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | | | | | | | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 61 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | | | | | 86 67 68 69 70 | | PAGE |
| 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 61 62 53 54 56 57 58 59 50 61 62 63 64 58 66 67 68 89 70 17 17 17 17 17 17 18 18 77 17 18 19 80 | (15) | | | | | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | 7 OF |
| 76 77 78 7980 | (5X) | | | | · | | 6 77 78 79 80 | | 7 |

Amplification of Card Type TSX

Card Type TSX signals the end of cards associated with ship type NST. Each ship type data set must be followed by exactly one card of this type. Upon reading this card, program control is returned to the Type Generator.

Card Columns

1-3

Description

"TSX" label indicating that all inputs defining ship type NST have been read.

| | FORMAT | LABEL | OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|---------|----------------|------------------|--|------------------------------------|---|------------------|-----------------------|
| 1 2 3 | TT | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | ER T | TI |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20н) | (ACARD) | (Alpha) | | Target Type name | TGTNM (I, NT), I = 1, N20BCD | 6 7 8 9 10 11 12 13 14 15 16 17 1 | | PURPOSE |
| 8 19 20 21 22 23 24 25 26 | | | | | | | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 | TYPGEN U | Target Type Data Card |
| 5 27 28 29 30 | (15) | NT | 1 to NTTMAX | integer | Target Type number | N/A | 5 27 28 29 30 | ROUTINE | ırd |
| 31 32 33 34 35 | (15) | MVG | 1 to NTTMAX | integer | Vulnerability Group index value | NTGPAR _d (NT) | 31 32 33 34 35 | TGTGEN | |
| 36 37 38 39 40 | (51) | SCOW | 1 to NTTMAX | integer | Cross Section Group index value | NTGPAR _e (NT) | 36 37 38 39 40 | | |
| 47 42 43 44 46 | (15) | | 0 to 1023 | feet | DEC/CEP (interpretation of this field depends on the value in the REP/Option field following) | NTGPAR _f (NT) | 41 42 43 44 45 | REMARKS | |
| 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 46 40 47 48 49 50 61 52 53 54 5 | (15) | | 0 to 1023 | feet | REP/"O' (if equal to "O", then DEP/ CEP field is interpreted as CEP; otherwise this is REP, and DEP/CEP is taken to be DEP) | NTGPAR _g (NT) | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| | (15) | | 0 or 1 only | integer | Guidance Dependency 0 - autonomous 1 - dependent | NTGPAR _A (NT) | | | |
| 56 57 58 59 50 | (15) | | 0 to 32,767 | pounds | Warhead lethality in equivalent pounds of TNT (N/A to nonimpacting Target Types) | NTGPAR ₁ (NT) | 56 57 58 59 60 | | |
| 61 62 63 64 66 | (15) | | 0 to 1023 | ft/sec | Standard deviation of speed for weapon profile of impacting Target Types | NTGPAR _h (NT) | 57 58 59 60 61 62 63 64 65 66 67 68 69 | | |
| 86 67 88 89 70 | (15) | | 0 to | feet | Fuze delay distance (impacting target) | NTGPAR _j (NT) | 12 | | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | 0 to 100 | integer | 100 x probability target a dud (impacting target) | NTGPAR _k (NT) | 71 72 73 74 75 76 77 78 79 80 | | E 1 OF |
| 76 77 78 7980 | (\$ X) | | | centi- meters | Missile sensor wavelength λ (impacting target) | NTGPAR ₁ (NT) | 76 77 78 79 80 | | - |

Amplification of Card Type TT

| Card Columns | <u>Description</u> |
|--------------|--|
| 1-2 | The label "TT" indicates that this is a target-type data card. |
| 6-25 | 20-character field which may be used to assign a name to this target type. |
| 26-30 | Identification number for this target type. It may be used as a reference number when generating targets (aircraft and parasites) in the Raid Generator. |
| 31-35 | The vulnerability group index is correlated with missile-lethality data to assess damage to a target. |
| 36-40 | This value corresponds to a cross-section group that has been defined on Card Types TC and TCD. |
| 41-45 | This and the following field correspond to guidance accuracy. This field is interpreted as CEP (circular error probable) if columns 46-50 of this card are blank or 0; otherwise, it is DEP (deflection error probable). Two cases must be considered. If this is the target type for a nonimpacting target, then DEP/REP or CEP determines the aimpoint in relation to the center of the ship under attack. (If the weapon being fired has autonomous inflight guidance, then the launch plane does not influence the aimpoint.) For an impacting target, the DEP/REP or CEP determines the impact point in relation to the aimpoint. |
| 46-50 | A nonzero value represents REP; 0 means that columns 41-45 are to be interpreted as CEP. For an explanation of this field see the description for columns 41-45 of this card type. |
| 51-55 | A value of 1 indicates that this target type requires inflight guidance from its parent launch vehicle; 0 means that it does not. This field does not apply to nonimpacting target types. |

Amplification of Card Type TT (Concluded)

| Card Columns | Description |
|--------------|--|
| 56-55 | Warhead lethality in equivalent pounds of TNTthis field applies only to impacting target types. |
| 61-65 | Standard deviation of speed for the weapon profile of an impacting target type. |
| 66-70 | Fuze delay distance for an impacting target, expressed in feet; zero or blank otherwise. |
| 71-75 | $100\ x$ probability impacting target is a dud; zero or blank otherwise. |
| 76-80 | $\lambda_{\text{,}}$ missile sensor wavelength of impacting target, expressed in centimeters; zero or blank otherwise. |

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|-------|------------------|-------------|--|--------------------------|----------------------|
| 1 2 3 | ΤX | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | 1 | |
| | | | | | | | 6 7 8 9 1011 | 1 RI | ΪX |
| 12 13 14 15 16 1 | (20H) | : | | | | | 12 13 14 15 16 | READING . | PURPOSE Tr |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 59 56 50 51 62 63 64 65 66 67 68 69 70/1 72 73 74 75 76 77 78 79 80 | | | | | | | 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | TYPGEN | Trailer Card for the |
| 26 27 28 29 30 | (15) | | | | | | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | ROUTINE | e Type Generator |
| 31 32 33 34 35 | (15) | | | | | | 11 32 33 34 35 3 | TYPGEN | erator |
| 36 37 38 39 40 | (15) | | | | | | 6 37 38 39 40 4 | | |
| 41 42 43 44 45 | (15) | | | | | | 1 42 43 44 45 | REMARKS | |
| 66 47 48 49 50 | (15) | | | | | | 6 47 48 49 50 | | |
| 51 52 53 54 55 E | (15) | | | | | | 1525354555 | | |
| 6 57 58 59 60 | (15) | | | | | | 6 57 58 59 60 6 | Terminates "TYPE" Inputs | |
| 162 63 64 65 6 | (15) | | | | | | 1 62 63 64 65 (| "TYPE" I | |
| 6 67 68 69 707 | (15) | _ | | | | | 6 67 68 69 70 | puts | PAGE |
| 1 72 73 74 75 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | 1 OF |
| 16 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 6 77 78 79 80 | | 1 |

Amplification of Card Type TX

This card is the final Type data card. It must be present in the card deck; its absence will cause termination of the Pregame Processor program. It is worth noting that if Type data are being read from tape and there are to be no additions or modifications from the card file, the first and only Type data card would be a card of this type.

After reading this card a check is made to see if errors have been detected. All Type data will be written onto tape if the data are error free and a write request has been made on Card Type C. This concludes the Type Generator inputs and is a signal to begin reading Defense Generator cards.

| | FORMAT | LOCAL | OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|--------|--------|-------------------|---------|--------------------------|---|--|--------------------|-----------------------|
| 7 | | | | | Label | N/A | 12345 | FORMAT | CARO |
| 5 | _ | | | | (Unused Integer) | N/A | \$ 5 | AT ER | BF |
| 6 7 8 9 10 | ۱_ | IFCN | ≥0 | integer | Boolean function number | IBOLFN _a (I) | 6 7 8 9 10 | 7 | F |
| 11 12 13 14 15 | (15) | ILOGIC | AND or OR only | | AND/OR logic designation | IBOLFN _d (I) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 6 17 18 19 20 | (15) | | >0 | integer | Boolean variable number | IBOLV (IBOLFN _b (I)) | 16 17 18 19 20 | Bolgen | Boolean F |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (15) | | ≥0 | integer | Boolean variable number | IBOLV _a (IBOLGN _b (I)+1) | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | Boolean Function Card |
| 26 27 28 29 30 | (15) | | | | ÷ | | 26 27 28 29 30 | ROUTINE | rd |
| 31 32 33 34 35 | (15) | | | | | | | Bolgen | |
| 36 37 38 39 40 | (15) | | | | | | | | |
| 41 42 43 44 46 | (15) | | | | | | 41 42 43 44 46 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | : | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| | (15) | | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | | |
| 31 62 63 64 65 6 | (15) | | | | | | 61 62 63 64 65 | | |
| 6 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 7071 72 73 74 75 76 77 78 79 80 | (15) | | ⊗ | integer | Boolean variable number | IBOLV _a (IBOLGN _b (I)+1) | 56 57 58 59 60 61 62 63 64 69 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | E 1 |
| 677 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | ω |

Amplification of Card Type BF

Boolean functions are the means by which the operational interdependencies of ship components are described. A master set of Boolean functions is defined for each replication, upon which each ship type defined for that replication may draw. Within ship type, each ship component is assigned a component ID number (see Card Type TSC). A Boolean function from the master set is associated with each ship component by matching Boolean function number with component ID number. If no Boolean function for a given component ID number exists, then the component is considered operationally independent of other components on the ship.

A Boolean function of the form used in this simulation is defined by specifying a Boolean function number, a logic indicator (either "AND" or "OR"), and a string of Boolean variable numbers. Note that a Boolean function here may have either "AND" or "OR" logic only and not a combination thereof; any component depending upon combination logic may be represented as depending upon a combination of dummy components whose Boolean functions are of the required form. The following are two examples of Boolean functions:

| <u>Boolean</u> | function No. | $\underline{\mathtt{Logic}}$ | Boolean variables |
|----------------|--------------|------------------------------|-------------------|
| Ex.1 | 4 | AND | 6, 8, 10 |
| Ex.2 | 7 | OR | 9, 11 |

Example 1 defines a hypothetical Boolean function number 4, the Boolean function to be associated with component number 4 within a given ship type. It is an "AND" logic function, indicating that component numbers 6, 8, and 10 within the given ship type must be operating in order for $\overline{\text{component}}$ number 4 to be functioning.

Example 2 illustrates the situation where component number 7 is dependent upon either component number 9 or component number 11 operating. Again, all component numbers refer to those within a given ship type, and must be unique within that ship type.

A component never appears as a Boolean variable in its own Boolean function. A component must obviously be "up" (mechanically in working condition) as well as "on" (Boolean function satisfied) to be operational.

One Card Type BF is required for each Boolean function. Boolean variables associated with a given Boolean function may overflow onto any number of BFC continuation cards.

Amplification of Card Type BF continued

| Card Columns | Description |
|--------------|--|
| 1-2 | "BF" label indicating this is a Boolean function card. |
| 6-10 | Boolean-function number. |
| 11-15 | Logic designator, "AND" or "OR", right justified in field. |
| 16-20 • | Boolean variable number. |
| 71-75 | Boolean variable number. |

| | FORMAT | LABEL | OF VALUES | ONITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|--------------|--------------|----------------------|---|---|--------------|------------------------------------|
| 1 2 3 | BFC | | | | Label | N/A | 123 | NUMBER | CARD NAME |
| 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | ΞĀ | |
| 6 7 8 9 10 1 | (15) | | | | | | 6 7 8 9 10 | 7 | BFC |
| 1 12 13 14 151 | (15) | | | | | | 11 12 13 14 15 | READING | PURPOSE |
| 6 17 18 19 20 | (15) | | > 0 | integer | Boolean Variable No. | IBOLV _a (IBOLFN _b (I)+j) | 16 17 18 19 20 | BOLGEN | Boolean F |
| 21 22 23 24 25 | (15) | ļ | | | : | | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | Boolean Function Continuation Card |
| 7 8 9 10 111 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 50 | (3 I) | | | | | | 26 27 28 29 30 | USING BOLGEN | ntinuation |
| 31 32 33 34 35 | (15) | | | | | | 31 32 33 34 35 | BOLGEN | Card |
| 36 37 38 39 40 | (15) | - | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 66 47 48 49 50 | (15) | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 54 55 | (15) | | | | | | | | |
| 56 57 58 59 50 | (15) | | | | | | S 57 58 59 60 | | |
| 1 62 63 64 65 6 | (IS) | · | | | | | P3 63 63 63 63 | | |
| 56 57 58 59 50 61 62 63 64 66 66 67 68 69 7071 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 86 67 68 60 70 | - | PAGE |
| 72 73 74 | (I5) | | | | | | 7777 | | 2 |
| 25 | + | | | \downarrow | | | | | 읶 |
| 77 78 79 80 | (5X) | | | | | 11 10 13 00 | | | ω |

Amplification of Card Type BFC

Card Type BFC is a Boolean-function-continuation card. Each Boolean-function BF card may be followed by as many BFC cards as necessary to list all Boolean variable numbers included for that function.

| Card Columns | Description | | | | |
|--------------|--|--|--|--|--|
| 1-3 | "BFC" label indicating this is a Boolean function continuation card. | | | | |
| 16-20 | Boolean variable number. | | | | |
| • | • | | | | |
| • | • | | | | |
| 71-75 | Boolean variable number. | | | | |

| Ш | FORMAT | LABEL | VALUES | RANGE | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|---------------------------------------|--------|-------|-------|------------------|-------------|--|--------------------|-------------------|
| 1 2 3 | BX | | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 5 | (21) | | | | | (Unused Integer) | N/A | 5 | ΞĀ | |
| 6 7 8 9 10 | (15) | | | | | · | | 6 7 8 9 10 | 7 | BX |
| 11 12 13 14 15 | (15) | | | | | | | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (21) | | | | | | | 5 16 17 18 19 20 | BOLGEN | Trailer Card |
| 21 22 23 24 2 | (15) | | | | | · · | | 0 21 22 23 24 25 | | for |
| 26 27 28 29 30 | (15) | | | | | | | 5 26 27 28 29 3 | ROUTINE | Boolean Functions |
| 31 32 33 34 35 | (15) | · · · · · · · · · · · · · · · · · · · | | | | | | 0 31 32 33 34 3 | ROUTINE BOLGEN | nctions |
| 36 37 38 39 40 | (15) | | | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (IS) | | .s | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 50 | (51) | | | | | | | 56 57 58 59 60 | | |
| 1 62 63 64 65 6 | (75) | | · | | | | | 61 62 63 64 69 | | |
| 667 68 69 707 | | | | | | | | 66 67 68 69 70 | | PAGE |
| 172 73 74 | | 1 | | | | | · | 77 77 77 | | ω |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 21 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 50 61 62 63 64 66 66 66 70 71 72 73 74 76 76 77 78 79 60 | + | | | + | + | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 68 67 68 69 70 71 77 77 74 78 76 77 78 70 80 | | OF 3 |

Amplification of Card Type BX

Card Type BX signals the end of Boolean function cards and must always appear in the input deck. The Boolean function input cards, if any, followed immediately by this trailer card are positioned in the input deck immediately after the type generator trailer card (Card Type TX) and preceding the first defense generator card (Card Type DF).

Card Columns

Description

1-2

"BX" label indicating that all Boolean function cards have been read.

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|---------|---------|--------------------------------|----------------|--|----------------------------------|---|------------------|-------------------------------|
| 123 | DF | | | | Label | n/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (I 2) | | 0,1 | int | Position data input option 0 - rectangular, 1 - cylindrical | n/a | 4 5 | AT ER | |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 64 55 56 | (20н) | (ACARD) | (Alpha) | | Defense Unit name | SHIPNM (1,ISN), I=1,N2OBCD | 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | 4 READING DEFGEN | DF PURPOSE Defensive Unit Des |
| 26 27 28 29 30 | (15) | ISN | 1 to ISMAX | integer | Defense Unit number | n/a | 26 27 28 29 30 | USING ROUTINE | Descriptor Card |
| 31 32 33 34 36 | (15) | TSN | 1 to 31 | integer | Ship Type number | ISHPFO _b | 31 32 33 34 35 | DEFGEN | rd |
| 36 37 38 39 40 | (15) | | 1 to 31 | integer | TEWA Group number | ISHPFO _C | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | 0 to 360 | degrees | Ship heading CW from North | ISHPFO (ISN) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | if cylindrical then Rho ≥ 0 | kft | X coordinate in kft, or Rho value in kft | SHIPOS (1,ISN) | 46 47 48 49 50 51 52 53 54 55 | | |
| 56 57 58 59 50 61 62 63 64 65 | (F10.3) | | | kft or degrees | Y coordinate in kft, or Theta value in degrees, clockwise from North | SHIPOS (2,ISN) | 56 57 58 59 60 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | ≥ 0 | kft | Z coordinate in kft | SHIPOS (3,ISN) | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | 2 |

Amplification of Card Type DF

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "DF" indicates that this is a defense unit card. |
| 5 | Option number for the position data contained in columns 46-75: |
| | Option 0: rectangular coordinates (X,Y,Z) Option 1: cylindrical coordinates (ρ , θ ,Z), |
| 6-25 | 20-character field which may be used to assign a name to the defense unit being defined. |
| 26-30 | Identification number, ISN, for this defense unit. |
| 31-35 | Ship Type number to be associated with this defense unit (refers to a data set defined by Card Types TS, TSR, TSG, TSV within TYPGEN). |
| 36-40 | Threat evaluation and weapon assignment (TEWA) group number. Defense units having the same TEWA group number may share information pertaining to missiletarget assignments, as communications links status will allow. |
| 41-45 | Ship heading, clockwise from North (i.e., from the positive Y axis). Since there is no movement of defense units during the simulation, the heading information is used exclusively for determining component locations (e.g., radars and launchers) for evaluation of ship damage after an enemy weapon-impact event. |
| 46-55 | Either the X-coordinate or the rho value of the defense unit's position, depending on the position data option in card column 5. |

Amplification of Card Type DF (Concluded)

| Card Columns | Description |
|--------------|--|
| 56-65 | Either the Y-coordinate or the theta value of the defense unit's position, depending on the position data option in card column 5. |
| 66-75 | The defense unit's Z-coordinate. |

| | FORMAT | LABEL | RANGE OF VALUES | SLINO | DESCRIPTION | DISPOSITION |] | | |
|--|---------|-------|------------------------|----------------|---|-------------|---|---------------------------|-----------------------|
| 1 2 3 | DΧ | | | | Label | N/A | 1 2 3 | FORMAT | CARD NAME |
| 4 5 | (12) | | 0,1 | int. | Position data input option 0 - rectangular, 1 - polar | N/A | 4 5 | | |
| 67891011 | | | | | | | 6 7 8 9 1011 | 4 R | DX |
| 12 13 14 15 16 17 | (20H) | | | | | | 12 13 14 15 16 1 | READING I | PURPOSE Tra |
| 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | | | | | | 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | DEFGEN | Trailer Card for t |
| 26 27 28 29 30 | (51) | | | | | | 26 27 28 29 30 | USING ROUTINE | the Defense Generator |
| 3) 32 33 34 35 3 | (15) | | · | | | | 31 32 33 34 35 36 | DEFGEN | Generator |
| 6 37 38 39 40 4 | (15) | | | | | | 36 37 38 39 40 41 | R | |
| 1 42 43 44 45 | (15) | | | | | | 42 43 44 45 | REMARKS | : |
| 16 47 48 49 50 51 52 53 54 55 | (F10.3) | | if polar then Rho≥0 | kft | Vital Area Center X coordinate in kft, or Rho value in kft | VAC(1) | 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | | |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | kft or degrees | Vital Area Center Y coordinate in kft, or Theta value in degrees, clockwise from North | VAC (2) | 57 58 59 60 61 62 63 64 65 | Terminates Defense Inputs | |
| 36 67 68 69 70 71 72 73 74 75 | (F10.3) | | | | | | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | Inputs | PAGE 2 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | 22 |

Amplification of Card Type DX

| Card Column | Description |
|----------------|---|
| 1-2 | The label "DX" indicates that all inputs to the Defense Generator have been read. This card causes return of execution control to the GENER8 program. |
| 5 | Option number for the Vital Area Center (VAC) position data contained in columns 46-65: |
| | Option 0: rectangular coordinates (X, Y) Option 1: polar coordinates (ρ , θ) |
| 46-55 | Either the X-coordinate or the rho value of the Vital Area Center, depending on the position data option in card column 5. |
| 56 -6 5 | Either the Y-coordinate or the theta value of the Vital Area Center, depending on the position data option in card column 5. |

| | FORMAT | LOCAL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION |] | | |
|---|--------|-------|-----------------------|---------|--|-----------------------------------|-------------------------------|--------------------|--------------------|
| 1 2 3 | SR | | | | Label | n/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | П | (Unused Integer) | N/A | 5 | RΤ | |
| 678910 | (15) | ISN | 1 to ISMAX | integer | Defense Unit number | | 6 7 8 9 10 | 3 | SR |
| 11 | (15) | IOR | 0 or 1 only | integer | Sector boundary reference option 0 - CW from North 1 - CW from the bow | | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | 0 < | integer | NR_1 , the number of the first radar set for which a search sector is defined | | 16 17 18 19 20 | SECCEN | Surveillance |
| 21 22 23 24 25 | (15) | | ≥ 0 | degrees | ${ m RR}_1$, the right hand boundary of the search sector for radar set ${ m NR}_1$ | RSECT (IBR+NR ₁ -1) | 21 22 23 24 25 | | ınce Radar |
| 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (15) | | ≥ 0 | degrees | WR_1 , the width of the search sector for radar set NR_1 , measured CCW from RR_1 | WIDE (IBR+NR ₁ -1) | 26 27 28 29 30 | USING ROUTINE | Search |
| 31 32 33 34 35 | (15) | | > 0 | integer | NR ₂ | | 31 32 33 34 35 | SECGEN | Sector Definitions |
| 36 37 38 39 40 | (15) | | ≥ 0 | degrees | RR ₂ | RSECT (IBR+NR ₂ -1) | 32 33 34 35 36 37 38 39 40 | | nitions |
| 41 42 43 44 45 | (15) | | > 0 | degrees | WR ₂ | WIDE (IBR+NR ₂ -1) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | ≥ 0 | integer | NR ₃ | | 46 47 48 49 50 | | |
| 51 52 53 34 55 | (15) | | ≥ 0 | degrees | RR ₃ | RSECT (IBR+NR ₃ -1) | 51 52 53 54 55 5 | | |
| 56 57 58 59 50 | (15) | | ≥ 0 | degrees | wr ₃ | WIDE (IBR+NR ₃ -1) | 5 57 58 59 60 | | |
| 6162636465 | (15) | | ≥ 0 | integer | NR 4 | | 61 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | 0 | degrees | RR ₄ | RSECT (IBR+NR ₄ -1) | 66 67 68 69 70 71 72 73 74 75 | | PAGE |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | ≥ 0 | degrees | wr ₄ | WIDE (IBR+NR ₄ -1) | 71 72 73 74 75 | | 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | အ |

Amplification of Card Type SR

This card type may be used to override the search sector default option (full coverage) for individual surveillance radar sets.

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "SR" indicates that this is a surveillance radar search-sector-definition card. |
| 6-10 | Identification number, ISN, for the defense unit to which the sector data on this card applies. |
| 15 | Option number for the right-hand sector boundaries, RR i |
| | Option 0: Boundaries are measured in degrees CW from North |
| | Option 1: Boundaries are measured in degrees CW from the bow (the value of the ship heading will be added to all radar sector boundaries for this ship if this option is selected). |
| 16-20 | NR ₁ . The first radar set, relative to the Ship Type (NST) of Defense Unit ISN, for which a search sector is defined. If IBR is the task-force identification number of the first radar set for Defense Unit ISN, then the task force identification number of the radar set for which a coverage sector is being defined is IBR+NR ₁ -1. If NR ₁ is zero, the 3-tuple (NR ₁ , RR ₁ , WR ₁) is ignored. If NR ₁ is greater than the number of radars on Ship Type NST, then: (1) an error is recorded, and (2) RR ₁ and WR ₁ are ignored. |

Amplification of Card Type SR (Concluded)

| Card Columns | Description |
|--------------|--|
| 21-25 | RR ₁ . The right hand boundary of the search sector |
| | for radar set NR , measured in degrees from the |
| | reference specified in column 15. |
| 26-30 | WR ₁ . The width of the search sector for radar set |
| | $^{ m NR}_{ m 1}$, measured in degrees CCW from the right hand |
| | sector boundary RR ₁ . |
| 31-45 | The 3-tuple (NR $_2$, RR $_2$, WR $_2$) for the second search |
| | sector, defined as above. |
| 46-60 | The 3-tuple (NR $_3$, RR $_3$, WR $_3$) for the third search |
| | sector, defined as above. |
| 61-75 | The 3-tuple (NR $_4$, RR $_4$, WR $_4$) for the fourth search |
| | sector, defined as above. |

If there are more than four search sectors to be defined for a particular defense unit, then additional cards of Type SR would be used as appropriate.

| • | 1 | · | | _ | <u> </u> | | 7 | | |
|---|--------|-------|-----------------------|---------|---|------------------------------------|---|--------------------|--------------|
| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | SL | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 1.5 | (12) | | | | (Unused Integer) | N/A | 4 5 | RAT | |
| 6 7 | (15) | I SN | 1 to ISMAX | integer | Defense Unit number | | 6 7 8 9 10 | 3 | TS |
| 8 9 10 11 12 13 14 15 16 | (15) | IOL | 0 or 1 only | integer | Sector boundary reference option 0 - CW from North 1 - CW from the bow | | 111 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | ≥ 0 | integer | ${ m NL}_1$, the number of the first launcher for which a fire sector and/or salvo size is defined | | 16 | SECCEN | Launcher |
| 17 18 19 20 21 22 23 24 25 | (15) | | ≥ 0 | degrees | \mathtt{RL}_1 , the right hand boundary of the fire sector for launcher \mathtt{NL}_1 | RSECTL (IBL+NL ₁ -1) | 17 18 19 20 21 22 23 24 25 | | Fire Sector |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 | (15) | | ≥ 0 | degrees | WL_1 , the width of the fire sector for launcher NL_1 , measured CCW from RL_1 | WIDEL (IBL+NL ₁ -1) | 26 27 28 29 30 | USING ROUTINE | and |
| 31 32 33 34 35 | (15) | | ≥ 0 | integer | ${	t NSS}_1$, the salvo size for launcher ${	t NL}_1$ | (NL ₁) | 31 32 33 34 35 | SECGEN | Salvo Size I |
| 36 37 38 39 40 | (15) | | ≥ 0 | integer | NL ₂ | | 36 37 38 39 40 | | Definitions |
| 41 42 43 44 45 | (15) | | ≥ 0 | degrees | RL ₂ | RSECTL (IBL+NL ₂ -1) | 41 42 43 44 45 | REMARKS | S |
| 46 47 48 49 50 | (15) | | v 0 | degrees | WL ₂ | WIDEL (IBL+NL ₂ -1) | 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 47 48 49 50 51 52 53 54 55 56 | (15) | | ⊳ 0 | integer | nss ₂ | LAUNFO (NL ₂) | 51 52 53 54 55 | | |
| | (15) | | * 0 | integer | NL 3 | | 56 57 58 59 60 | | į |
| 6162 63 64 65 | (15) | | ≥ 0 | degrees | RL ₃ | RSECTL (IBL+NL ₃ -1) | 61 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | ≥ 0 | degrees | wL ₃ | WIDEL (IBL+NL ₃ -1) | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 71 72 73 | (15) | | ≥ 0 | integer | nss ₃ | LAUNFO | 71727 | | 2 |
| 74 75 | ~ | | | ger | 3 | (NL ₃) n | 37475 | | 믺 |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 7071 72 73 74 75 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | 3 |

Amplification of Card Type SL

This card type may be used to override the fire_zone_sector default option (full coverage) and/or the salvo_size default value (single missile salvo) for individual missile launchers.

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "SL" indicates that this is a launcher fire zone sector and salvo size definition card. |
| 6-10 | Identification number, ISN, for the defense unit to which the sector and salvo size data on this card applies. |
| 15 | Option number for the right-hand sector boundaries, RL . |
| | Option 0: Boundaries are measured in degrees CW from North Option 1: Boundaries are measured in degrees CW from the bow (the value of the ship heading will be added to all launcher sector boundaries for this ship if this option is selected). |
| 16-20 | NL ₁ . The first launcher, relative to the Ship Type (NST) of Defense Unit ISN, for which a fire zone sector and/or salvo_size is defined. If IBL is the task force identification number of the first launcher for Defense Unit ISN, then the task force identification number of the launcher for which data is being defined is IBL+NL ₁ -1. |
| | If NL is zero, the 4-tuple (NL, RL, WL, NSS) is ignored. If NL is greater than the number of launchers on Ship Type NST, then: (1) an error is recorded, and (2) RL, WL, and NSS are ignored. |

Amplification of Card Type SL (Concluded)

| Card Columns | Description |
|--------------|--|
| 21-25 | RL . The right hand boundary of the fire zone sector |
| | for launcher NL, measured in degrees from the reference |
| | specified in column 15. |
| 26-30 | \mathtt{WL}_1 . The width of the fire zone sector for launcher |
| | NL, measured in degrees CCW from the right hand sector |
| | boundary RL . A value of 0 will inhibit any firings |
| | from launcher NL ₁ . |
| 31-35 | NSS ₁ . The salvo size for launcher NL ₁ . If left blank |
| | or zero, the default value of 1 will be assumed. If greater than the number of rails for a launcher of this type, a nonfatal error will be recorded. |
| 36-55 | The 4-tuple (NL $_2$, RL $_2$, WL $_2$, NSS $_2$) for the second fire |
| | zone sector and salvo size, defined as above. |
| 56-75 | The 4-tuple (NL $_3$, RL $_3$, WL $_3$, NSS $_3$) for the third fire |
| | zone sector and salvo size, defined as above. |

If fire-zone sectors and salvo sizes are to be defined for more than three launchers on a particular defense unit, then additional cards of Type SL would be used as appropriate.

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|---|--------|-------|-----------------------|-------|------------------|-------------|---|------------------|---------------------------------------|
| 123 | X S | | | | Label | N/A | 1 2 3 | NUMBER NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | X/A | 4 5 | 37.C | |
| 6789101 | | • | | | | | 6 7 8 9 10 | 3 | SX |
| 1 12 13 14 15 | | | | | | | 11 12 13 14 15 | RE ADING | PURPOSE |
| 16 17 18 19 20 | | | | | | | 16 17 18 19 20 | SECGEN | Trailer (|
| 21 22 23 24 25 | | | | | | | 21 22 23 24 25 | | ard for t |
| 9 10 11 12, 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 26 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 34 55 56 | | | | | | | 10 11 2 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 47 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | NSING ROUTINE | Trailer Card for the Sector Generator |
| 31 32 33 34 35 | | | | | | | 31 32 33 34 35 | SECGEN | Generator |
| 36 37 38 39 40 | | | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 45 | | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | | | | | | | 46 4/ 48 49 50 | | |
| 51 52 53 34 55 | | | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 50 | | | | | | | 56 57 58 59 60 | | |
| 61 62 63 64 65 | | | | | | | 01 02 03 04 05 | | |
| 66 67 68 69 70 | | | | | | | 00 07 00 09 70 | 2 2 2 2 2 2 | PAGE |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | | | | | | 5/ 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 75 60 | 31 27 27 38 | 3 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/a | 10 // /0 / 300 | 2000 | 3 |

Amplification of Card Type SX

Any number of cards (including none) of Types SR and SL may be included in the input deck for the Sector Generator; they may be freely intermixed and need not be ordered by defense unit number. The Type SX card signals that there are no more Type SR or Type SL cards to be read.

Card Column

Description

1-2 The label "SX" indicates that all inputs to the Sector Generator have been read. This card causes return of execution control to the GENER8 program.

| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION |] | | |
|---|---------------|--|-----------------------|-----------|--|-----------------------------|---|--|--|
| 11 2 3 | T 0 R | | 0, | | Label | N/A | 1 2 | NOR VOR | CARD NAME |
| 3 4 5 | 112) | | | - | (Unused Integer) | N/A | 2 3 4 5 | FORMAT NUMBER | mο |
| 6 7 8 | Ĥ | ISN | l to ISMAX | integer | Defense Unit number to which this radar simulation model option data is applicable. | | 6789 | 6 | OR |
| 9 10 11 12 113 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 55 36 57 38 59 40 41 42 43 44 45 46 47 48 49 50 15 52 15 34 155 | (I2) | | | int. | IROPT, see text for explanation | IRADPC _C (IRB) | 10 | ROR | <u> </u> |
| 213 14 | (12) (12) | | | int | IROPT ₂ | IRADPC _C (IRB+1) | 10 11 12 13 14 15 16 | READING ROUTINE | PURPOSE |
| 15 16 | (12) | | | int. | IROPT ₃ | IRADPC (IRB+2) | 4115 10 | , | J |
| 17 18 | | | | | | (211312) | 6 17 18 | | Radaı |
| 19 20 | | | | | | | 17 18 19 20 21 22 | OPTGEN | r Si |
| 21 22 | • | | • | | • | • | 21 22 | EN | mula |
| 23 24 | • | | • | | • | • | 23 24 | | tion |
| 25 26 | • | | • | | • | • | 25 | ᇙ | Radar Simulation Model Option Selections |
| 27 28 2 | \Box | | | | | | 27 28 29 | USING ROUTINE | e1 0 |
| 9 303 | | | | \perp | | | 29 30 | _ | ptio |
| 1 32 3: | 4 | | | 4 | | | 30313233 34 35 36 | Q. | n Se |
| 34 (2) | _ | | | 4 | | | 3343 | OPTGEN | lect |
| 36 | _ | | | 4 | | | 5 36 3 | | ions |
| 7 38 38 | 4 | - | | 4 | | | 37 38 39 40 | | |
| 6 | - | | | 4 | | | 404 | 긐 | |
| 42/43 | \dashv | | | - | | • | 42 43 | REMARKS | ļ |
| 4 | \dashv | | | \dashv | | | 41 42 43 44 45 46 | š | İ |
| 6 647 | + | | | \dashv | | | 46 47 | IRB | |
| 8 | \dashv | | + | + | | | 48 49 | 11 | |
| 5051 | ╅ | | | \dashv | | | 50 51 | he t | |
| 5253 | \dashv | | | + | | | 52 53 | ask | |
| 54 55 | + | | | + | | | 47 48 49 50 51 52 53 54 55 56 | for | |
| 56 57 E | \dashv | | | + | Prince Annual Control of the Control | <u> </u> | 56 57 | | |
| 8 59 5 | + | | | + | | | 8 59 | lenti | |
| 616 | \top | | | \dagger | | | 190 | fice | |
| 63 62 | + | | $\neg \dagger$ | \top | | | 2 63 6 | tio | |
| 65 66 | \top | $\neg \uparrow$ | \neg | + | | | 465 6 | nu r | |
| 67 88 | 1 | | | 十 | - | | 6676 | mber | |
| 69 70 | | | | T | | - | 869 7 | <u>e</u> | PAGE |
| 71 72 | (12) (12) | | | _ | | | 9777 | the | |
| 73 74 | (3 x) | | | | | | 27374 | firs | |
| 75 X | + | | | + | | | 17576 | st r | 유 |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (5x) | | | | (Sequence Field) | n/A | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | identification number of the first radar | ω |

Amplification of Card Type OR

This card type may be used to override the radar simulation model default option (simple cookie-cutter) for individual radar sets.

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "OR" indicates that this is a radar simulation model definition card. |
| 6-10 | Identification number, ISN, for the defense unit to which the model option data on this card applies. |
| 12 | The radar simulation model option to be used with the first surveillance radar set aboard Defense Unit ISN. Any value for which no radar simulation model option has been programmed will be replaced with the default value of 1. |
| : | • • • • • • • • • • • • • • • • • • • |
| 2i+10 | The radar simulation model option to be used with the ith surveillance radar set aboard Defense Unit ISN. |

| | FORMAT | LABEL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION |] | | |
|--|-----------|-------------|-----------------------|----------|--|--------------------------------|---|--|---|
| 1 2 | T OG | | s m | | Label | n/A | 1 2 | FORMAT NUMBER | CARD NAME |
| 3 4 5 | (I2) | | | | (Unused Integer) | n/A | 3 4 5 | MAT BER | E O |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 | (15) | ISN | 1 to ISMAX | integer | Defense Unit number to which this guidance channel group simulation model option data is applicable. | | 67891 | 6 | QG |
| 1112 | (12) | | | int. | IGOPT ₁ , see text for explanation | JGCGRP _d (IGB) | 11 12 | RE A | Ş |
| 13 14 | (12) (12) | | | int. | IGOPT ₂ | JGCGRP _d (IGB+1) | 13 14 | READING ROUTINE | PURPOSE |
| 15 16 | (12) | | | int | IGOPT ₃ | JGCGRP _d (IGB+2) | 15 16 | | |
| 17 18 | | | | | | | 17 18 | ဍ | uida |
| 19 20 | | | | | | | 19 20 21 22 | OPTGEN | ance |
| 21 22 | • | | • | | • | • | | _ | Chai |
| 23 24 2 | • | | • | | • | • | 23 24 2 | | Guidance Channel Group Simulation Model Option Selections |
| 5 26 2 | • | | • | | • | • | 25 26 2 | USING | Grot |
| 7 28 2 | | | | | | | 27 28 29 | UTINE | is dr |
| 9 30 3 | | | | _ | | | | | mul: |
| 32/33 | | | | | | | 18 | OP. | ation |
| 34 35 | Н | | | _ | | | 33 34 35 | OPTGEN | ı Moç |
| 36 37 | | | | \vdash | | | 36 37 | İ | del (|
| 38 39 | | | | - | | | 38 39 40 | | Opti |
| 40 41 | | | | | | | 10 41 42 | R | on S |
| 42 43 4 | | | | | | | 243 | REMARKS | elec |
| 45 4 | \neg | | | | | | 43 44 45 46 47 48 | | tion |
| 6 47 4 | | | | 寸 | | | 6474 | IGB = | ν |
| 8 49 5 | _ | | | | | | 9 50 | | |
| 0515 | | | | | · · · · · · · · · · · · · · · · · · · | | 05152 | the task guidance | |
| 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 54 | | | | | | | 53 54 | k fo | |
| | | | | | | | 55 5 | force channe | |
| 57 58 | | | | | | | 57 58 | ider il gr | |
| 59 60 | | | | | | | 57 58 59 60 61 62 | tifi oup | |
| 61 62 | | | | | | | 61 62 | icat | |
| 63 64 | | | | _] | | | 63 64 | ion this | |
| 35 GG | | | | | | | 65 66 | numb shi | |
| 7 686 | _ | | | _ | | | 67 68 | er o | _ |
| 9 707 | (12) (12) | | | | | | 59 70 | identification number of the first el group on this ship | PAGE |
| 1 72 7 | 12) | | | _ | | | 71 727 | le fi | 20 |
| 3747 | (3X) | | | | • | | 3747 | irst | |
| 57677 | | | | \dashv | : | | 576 77 | | 유 |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | ω |

Amplification of Card Type OG

This card type may be used to override the radar simulation model default option (simple cookie-cutter) for individual guidance channel groups.

| Card Columns | Description | | | | |
|--------------|--|--|--|--|--|
| 1-2 | The label "OG" indicates that this is a guidance channel group simulation model definition card. | | | | |
| 6-10 | Identification number, ISN, for the defense unit to which the model option data on this card applies. | | | | |
| 12 | The radar simulation model option to be used with the first guidance-channel group aboard Defense Unit ISN. Any value for which no radar simulation model option has been programmed will be replaced with the default value of 1. | | | | |
| : | : • | | | | |
| 21+10 | The radar simulation model option to be used with the ith guidance-channel group aboard Defense Unit ISN. | | | | |

| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|----------|-------|-----------------------|--------------|------------------|-------------|---|--------------------|---------------------------------------|
| 1 2 3 | 0 X | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (I 2) | | | | (Unused Integer) | N/A | 4 5 | ER ER | |
| 6 7 | | | | | | | 6 7 8 | 6 | o x |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 28 30 23 32 33 34 35 36 37 38 23 40 41 42 43 44 45 46 47 48 48 50 51 52 53 54 55 56 | | | | | | | 9 10 | | |
| 11 12 | | | | | | | ======================================= | RE A | Ę |
| 13 14 | | | | | | | 11 12 13 14 15 16 | READING ROUTINE | PURPOSE |
| 15 16 1 | | | | | | | 15 16 | | Tr |
| 7 18 1 | | | | | | | 17 18 19 20 21 22 | đQ | Trailer Card |
| 9 20 2 | _ | | | | | | 9 20 2 | OPTGEN | r Ca |
| 1 22 23 | 4 | | | 4 | | | 1 22 2: | | rd f |
| 24 25 | 4 | | | _ | | | 3 24 28 | USING ROUTINE | for t |
| 26 27 | \dashv | | | \dashv | | | 26 27 | ROU | the Simulation Model Option Generator |
| 28 29 | - | | | \dashv | | | 28 29 | T S | í mul |
| 3031 | - | | | \dashv | | ` | 3031 | | atio |
| 32 33 3 | ᅥ | | | - | | | 313233 34 35 36 | OP. | Moc |
| 4353 | \neg | | | \exists | | | 4 35 3 | OPTGEN | del (|
| 6 37 30 | \dashv | | | | | | 6 37 36 | | Optio |
| 39 40 | | | | | | | 37 38 39 40 | | on Ge |
| 41 42 | | | | | | | 41 42 | REM. | ener |
| 4344 | \perp | | | | | | 41 42 43 44 45 46 47 48 49 50 | REMARKS | tor |
| 15 46 | \perp | | | | | | 45 46 | | İ |
| 7 48 4 | _ | | | _ | | | 17 48 4 | | |
| 9 50 5 | 4 | | | 4 | | | 9 50 5 | | |
| 52 53 | \dashv | | | \dashv | | | 1 52 53 | | |
| 34 55 | \dashv | | | \dashv | | | 51 52 53 54 55 56 | | |
| 56 57 58 | \dashv | | | \dashv | | | 56 57 58 | | |
| 58 59 6 | + | | | \dashv | | | 58 59 60 | | |
| 961 6. | \dashv | | | \dashv | | | 60 61 62 | | |
| 263 64 64 | 7 | | | \dashv | | | 2636 | | |
| 65 66 | | | | | | | 63 64 65 66 | | |
| 67 68 | \prod | | | | | | 67 66 | | |
| 69 70/ | | | | \int | | | 69 70 | [| PAGE |
| 1 727 | _ | | | \downarrow | | | 7172737475 | | ω |
| 3 74 75 | | | | | | | 73747 | | |
| 5 76 77 | _ | | | 7 | | | 576 7; | | 유 |
| 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 7980 | | ω |

Amplification of Card Type OX

Any number of cards (including none) of Types OR and OG may be included in the input deck for the Option Generator; they may be freely intermixed and need not be ordered by defense unit number. The Type OX card signals that there are no more Type OR or Type OG cards to be read.

Card Column

Description

1-2

The label "OX" indicates that all inputs to the radar simulation model Option Generator have been read. This card causes return of execution control to the GENER8 program.

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|---|--------------|-------|-----------------------|-----------|---|------------------------------------|----------------|--------------------|---|
| 1 2 3 | CM | | | | Label | n ∕A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 5 | (12) | | <u> </u> | | (Unused Integer) | n/a | 4 5 | æΉ | |
| 6 7 8 9 10 | (15) | WSI | 1 to ISMAX | integer | Defense Unit number to which this communication link modification data is applicable. | mmunication link modification data | | 6 | CM |
| 11 12 | (12) | | 니 및 O | int | OD ₁ , see text for explanation IMODIF (1,ISM) | | Ē | RE A | P |
| 13 14 | (12)(12)(12) | | 니 및 O | int. | IMOD ₂ | IMODIF (2,ISM) | 13 14 | READING ROUTINE | PURPOSE |
| 15 16 | (12) | | 1 or 0 | | IMOD ₃ | IMODIF (3,1SM) | 15 16 | | |
| 17 18 | | | | | | | 17.18 | | Ommu |
| 19 2 | | | | | | | 19 2 | COMGEN | mic |
| 0212 | _ | | | | | | 19 20 21 22 | ΕN | atio |
| 223 2 | | | | | | 1 | 23 24 | | E. |
| 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 | \vdash | | | | | | 12 | 7. | Communication Link Modification Inhibiting Card |
| 6 27 2 | | | | Н | | | 6 27 28 | USING ROUTIN | fodi |
| 28 29 | _ | | | | | | 13 | NE. | fica |
| 3031 | | | | Н | | | 303132 | | tior |
| 3233 | | | | - | | | 233 34 | COMGEN | Ę |
| 34 35 3 | | | | | | | 35 36 | EN | ibi |
|)G 37 3 | • | | • | | • | • | 637 38 | | ting |
| 37 38 39 40 | • | | • | Н | . • | • | 83940 | | Car |
| 1 | • | | • | | • | • | 4142 | REA | ٦ |
| 2434 | | | | | | | 43 4 | REMARKS | ı |
| 41 42 43 44 45 46 | | | | | | | 43 44 45 46 | S | |
| 6 47 4 | | | | | | | 64748 | | 1 |
| 8495 | | | | | | | 8 49 50 | | - 1 |
| 0515 | | | | | | | 05152 | | ľ |
| 47 48 49 50 51 52 53 5 | | | | | | | 2535 | | |
| 55 56 | | | | | | | 55 56 | | ł |
| | | | | \exists | | | 6 57 58 | | |
| 57 58 59 50 61 62 63 64 65 66 67 | 7 | | | | | | 8 59 60 | | |
| 616 | 7 | | | | | | d 61 62 | | |
| 636 | | | | \Box | | | 26364 | | |
| 65 6 | \dashv | | | | | | 8 | | |
| 676 | \dashv | | | + | | | 66 67 6 | | |
| 68 69 70 71 72 | E I | | ㅁ유 o | Ħ | IMOD ₃₀ | IMODIF (30,ISM) | 67 68 69 70 | ŀ | PAGE |
| 971 7 | [12](12 | | ႕ 및 O | int. | IMOD ₃₁ | IMODIF | 70 71 7 | | 36 |
| 2737 | ~ | | | +- | | (31,ISM) | 123 | | , |
| 4 75 | (3x) | | | _ | | | 7374757 | | 읶 |
| 73 74 75 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | ω |

Amplification of Card Type CM

One-way communications links between defense units (from a communications transmitter to a communications receiver) are treated within the simulation program as either "In" (reception possible) or "Out" (reception not possible). The current status of each such ship-to-ship link is maintained in the packed array ICOMM in common block TECOMM. The status of these links determines the degree to which information pertaining to radar detections and missile assignments may be shared among defense units.

Unless otherwise specified, all links are assumed to exist (i.e., to be "In") at the beginning of the game, and further all links are assumed to be subject to modification or disruption due to the effects of enemy communications jamming devices. Inputs, if any, to the Communications Generator (on Card Types CM and CS, which may be freely intermingled) override these default assumptions. Those links subject to modification are indicated in the packed array IMODIF in common block TECOMM. See also the amplification of columns 5-10 of Card Type CX which may override all Type CM cards, and/or all Type CS cards.

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "CM" indicates that this is a Communications Link Modification Inhibiting card. |
| 6-10 | The Defense Unit number, ISM, to which the data on this card is applicable. |
| 12 | A binary indicator specifying whether the communications link from defense unit 1 to defense unit ISM is (0) or is not (1) subject to modification by enemy jamming. |

Amplification of Card Type CM (Concluded)

<u>Card Columns</u> <u>Description</u>

(2i+10) This is a binary indicator as above for the link from Defense Unit i to Defense Unit ISM, where $i \le 31$.

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| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|---|----------|---------|-----------------------|----------|---|----------------------------|--|--------------------|----------------------------|
| 1 2 3 | cs ′ | | | | Label | n/A | 123 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | | | (Unused Integer) | n/A | 4 5 | ER ER | |
| 6 7 8 9 10 | (15) | ISX | 1 to ISMAX | integer | Defense Unit number to which this communications reception link initial status data is applicable | | 6 7 8 9 10 | 6 | cs |
| 11 12 | (12) | | 1 g 0 | int | ISTAT ₁ , see text for explanation | ICOMM (1,ISX) | 11 12 | READING ROUTINE | RUS |
| 13 | (12) | | 1 of 0 | int | I STAT ₂ | ICOMM (2,ISX) | 11 12 13 14 | TINE | PURPOSE |
| 14 15 16 | (12) | | 1 0 O | int. | ISTAT ₃ | ICOMM (3,ISX) | 15 16 | | |
| 17 18 | | | | , i | | | 17 18 | c | Ommu |
| 3 19 2 | | | | | | | 19 20 | COMGEN | nics |
| 19 20 21 22 | | | | | | | 21 22 | N | tio |
| 223 24 | | | | | | | 23 24 | | n Li |
| 13 | Н | | | \vdash | | | 25 | | Communication Link Initial |
| 26 27 28 | Н | | | | | | 6 27 28 | USING ROUTINE | [nit |
| 28 29 | | | <u> </u> | Н | | | | INE. | |
| 29 30 31 32 33 34 | | | | \vdash | | | 30 31 3 | | Status |
| 32 33 | Н | | - | ┝╌ | | | 31 32 33 34 | CO | sus |
| 34 35 36 | Н | | | _ | | | 35 36 | COMGEN | Card |
| 36 37 | | | • | - | • | - | 13 | | |
| 37 38 39 | • | | • | - | | • | 38 39 40 | | |
| 39 40 41 | - | | <u> </u> | _ | • | • | 12 | RE | |
| 41 42 43 44 45 46 47 48 | ÷ | | - | | | <u> </u> | 41 42 43 44 | REMARKS | |
| 14 45 | | | | _ | | | 45 | ŝ | |
| 46 47 | Н | | | _ | | <u> </u> | 46 47 | | |
| 48 49 | H | | | | | | 8 | | |
| 49 50 51 | Н | | | | | <u> </u> | 5051 | | |
| 51 52 53 34 | Н | | | - | | | 52535 | | |
| 5455 | \vdash | | | \vdash | | | 55 | | |
| 8 | - | | <u> </u> | - | | | 56 57 58 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 | \vdash | | <u> </u> | \vdash | | | 59 | | |
| 9 50 6 | H | | | \vdash | | | 60 61 | | |
| 1626 | Н | | - | ├- | | | 8 | ł | |
| 3 64 6 | Щ | | | ├ | | | 63 64 65 | | |
| 5 66 6 | Щ | | <u> </u> | \vdash | | | 8 | | |
| 7 686 | Ļ | | <u> </u> | <u> </u> | | TCOM | 7686 | | - |
| 9 707 | (12) | | ㅁ유 o | int. j | ISTAT ₃₀ | ICOMM (30,1SX) ICOMM | 9 70 7 | | PAGE |
| 1 72 7 | (EZ) | | ㅁ입 o | int. | ISTAT31 | (31,ISX) | 1727 | | 23 |
| 3747 | (XE) | | | | | | 3747 | | , |
| 73 74 75 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/A | 6768 69 70 71 72 73 74 75 76 77 78 79 80 | | OF 3 |

Amplification of Card Type CS

All one-way communications links between defense units are assumed to exist (i.e., to be "In") at the outset of the play of a game unless otherwise specified on one or more input cards of Type CS. One such card is required for each defense unit having an initial communications link status other than "reception from all other defense units is possible."

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "CS" indicates that this is a Communication Link Initial Status Card. |
| 6-10 | The Defense Unit number, ISX, to which the data on this card is applicable. |
| 12 | A binary indicator specifying whether the communications link from Defense Unit 1 to Defense Unit ISX does (0) or does not (1) exist at the outset of the game. |
| : | : : |
| (2i+10) | As above for the link from Defense Unit i to Defense Unit ISX, where i \leq 31. |

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|----------------|-------|-----------------------|--------------|--|-------------|-------------------------------|-----------------------|------------------------------|
| 11 2 3 | c x | | | | Label | n/A | 1 2 3 4 5 | FORMAT NUMBER | CARD NAME |
| 4 5 | | | | | (Unused Integer) | n/A | 4 5 | FAT | |
| 6 7 8 9 10 | Θ | ХООМ | See text | integer | Optional override of default values and/or Card Type CS and/or Card Type CM. See text. | - | 6789 | 6 | СX |
| 11 12 | (12) | | | | | | 01112 | R B B B B | P |
| 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 | (12) (12) (12) | | | | | | 2 13 14 15 | READING ROUTINE | PURPOSE |
| 15 16 | (E) | | | | | | 15 16 | | |
| 17 18 | | | | | | | | C | Trailer Card |
| 19 20 | | | | | | | 17 18 19 20 21 22 | COMGEN | er C |
| 21 22 | | | | | | | 21 22 | 22 | ard |
| 23 24 | | L | | | | | 23 24 | | for |
| 25 26 | | | | \Box | | | 181 | RU | the Communications Generator |
| 27 28 2 | | | | _ | | | 27 28 | USING ROUTINE | Comm |
| 9 303 | | | | _ | - | | 씽 | _ | lumic |
| 1 323 | | | | 4 | | <u></u> | 31 32 3; | 8 | atio |
| 33438 | _ | | _ | \dashv | | | 33 34 3 | COMGEN | ons (|
| 363 | | | | - | | | 35 36 3 | | ene |
| 3839 | 4 | | | \dashv | | | 7 38 39 | | rato |
| 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 5 | | | | \dashv | | | 37 38 39 40 41 42 43 44 45 46 | 2 | ~ |
| 42 43 | \dashv | | | \dashv | | | 42 43 | REMARKS | |
| 5 | - | | | + | | | 44 45 | S | 1 |
| | ┪ | | | \dashv | | | 46 47 48 | | ł |
| 89 | ┪ | | | \top | | | 18 4 9 50 | | |
| 6 15 | ┪ | | | 十 | | | 05152 | | |
| 53 5, | | | | 1 | | | 2 53 54 | | . |
| 55 56 | ٦ | | | 1 | | | 55 56 | | |
| 57 58 | | | | | | | 57 58 | | |
| 59 50 | | | | | | | 59 60 | | |
| 6162 | \prod | | | \prod | | | 61 62 | | |
| 63 64 | | | | \perp | | | 63 64 | | |
| 8 | \downarrow | | | \perp | | | 65 66 | | |
| 86 | 4 | | | \perp | | | 67 68 | ļ | |
| 9707 | 4 | | | \downarrow | | | 67 68 69 70 71 72 | | PAGE |
| 727: | 4 | | | 4 | | | 7777 | - [| ω l |
| 74 75 | | | | | , | | 3747 | | |
| 76 77 | _ | | o | 寸 | | - | 76 77 | | 유 |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 7980 | (5×) | | | | (Sequence Field) | N/A | 73 74 75 76 77 78 79 80 | | ω |

Amplification of Card Type CX

| Card Column | | Description |
|------------------|---------------|---|
| 1-2 | | CX" indicates that all inputs to the Communicator have been read. |
| 4-5 | the communi | cations default options and/or any cards of CS that may have been read. |
| | MODX = 0 | implies that all link specifications (including default values) stand as previously given. |
| | MODX = 1 | implies that no links may be modified but the initial status of each link is as previously specified. |
| | MODX = 2 | <pre>implies that no links may be modified and the initial status of all links is "Out."</pre> |
| | MODX = 3 | implies that all links are initially "Out" but links may be modified as previously specified. |
| | If MODX is | of any other value, it will be reset to "0." |
| The value | of MODIFY in | common block TECOMM is assigned at this time |
| to indicate that | at none (-1), | some (0), or all (+1) of the communications |

The value of MODIFY in common block TECOMM is assigned at this time to indicate that none (-1), some (0), or all (+1) of the communications links may be modified. The rules for assigning the value to MODIFY are as follows:

MODIFY = -1 if MODX = 1 or 2.

MODIFY = 0 if at least one card of Type CM has been read (and MODX = 0 or 3).

MODIFY = 1 if no cards of Type CM have been read (and MODX = 0 or 3).

Amplification of Card Type CX (Concluded)

Similarly the value of IXMIT in common block TECOMM is assigned to indicate that no links may ever exist (-1), some links may exist (0), or all links always exist (+1). The rules for assigning the value to IXMIT are as follows:

IXMIT = -1 if MODX = 2.

IXMIT = 1 if MODX = 1 and no cards of Type CS
have been read.

After the values have been assigned to MODIFY and IXMIT, execution control will be returned to the GENER8 program.

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ENVIRONMENTAL DATA CARD INPUT

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|---|---------|-------|-----------------------|------------|-----------------------------------|-------------|--|----------------|-------------------------|
| 1 2 3 | EN | | | | Label | N/A | 12345 | FORMAT | CARD NAME |
| 4 5 6 | (12) | | | | (Unused Integer) | N/A | 5 | RA. | н |
| 6 7 8 9 10 11 12 13 14 15 | (F10.3) | | | meters/sec | Wind speed | WINDSP | 5 7 8 9 101112131415 | 2 READING | EN PURPOSE |
| 7 8 9 10 11 12 13 14 15 16 17 16 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 6 152 53 54 55 | (F10.3) | | | meters | Altitude | ALTUDE | 16 17 18 19 20 21 22 23 24 25 | ENVGEN | Environmental data card |
| 26 27 28 29 30[3] 32 33 34 36 | (F10.3) | | 0 to 1 | integer | Nominal reflection coefficient | REFCOF | 303132333435 | ROUTINE ENVGEN | acard |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 41 42 43 44 46 | (15) | | | | | | 1 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (I5) | | | | | | 16 47 48 49 50 | | |
| | (15) | | | | | | 1 52 53 54 55 | | |
| 56 57 58 59 5Q | (I5) | | · | | | | 6 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 61 62 63 64 65 | | |
| 36 67 68 69 7 0 | (15) | | | | | | 86 67 68 69 7 q | | PAGE |
| 56 57 58 59 50 61 62 63 64 66 66 67 68 69 70 71 72 73 74 76 06 77 78 79 80 | (15) | | | | | | 56 57 58 59 60 61 62 63 64 65 86 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | : 1 OF |
| 76 77 78 7980 | (5X) | | | | | | 76 77 78 79 80 | | 2 |

Amplification of Card Type EN

Card Type EN furnishes the scenario environmental data for a game replication. This card, if present in the input deck (see Card Type EX for default option), must follow Card Type Cx, the Communications Generator trailer card.

| Card Columns | Description |
|--------------|---|
| 1-2 | "EN" label, indicating this is an environmental data card. |
| 6-15 | Wind speed, expressed in meters/second. |
| 16-25 | Altitude at which wind speed is taken, expressed in meters. |
| 26-35 | Nominal reflection coefficient. |

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|--------------------|-----------------------|-------|------------------|-------------|--|--------------------|---------------|
| 1 2 3 | EX | | | | Label | N/A | 1 2 3 | FORMAT | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | ERAT | EX |
| 6 7 8 9 10 | (15) | | | | | | 6 7 8 9 10 | 2 | |
| 11 12 13 14 15 | (15) | | | | | | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | | | | | 16 17 18 19 20 | ENVGEN | Environmental |
| 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | | | | | | 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | | ental Data |
| 5 26 27 28 29 | (15) | | | | | | 5 26 27 28 29 3 | HOUT INE | Trailer |
| 30 31 32 33 34 3 | (15) | | | | | | 26 27 28 29 30 31 32 33 34 35 | ENVGEN | Card |
| 5 36 37 38 39 4 | (15) | | | | | | 36 37 38 39 40 | | |
| 041 42 43 44 4 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | * <u>*</u> . · · · | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 54 59 | (15) | | | | | | | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | | |
| 61 62 63 64 65 | (15) | | | | | | 61 62 63 64 65 | | |
| 66 67 68 69 70 | (15) | | | | | | 66 67 68 69 70 | | PAGE |
| 26 27 28 79 30\$31 32 33 34 35 37 38 39 40\1 42 43 44 46\46 47 48 49 50\6 15 25 3 54 55\6 55 7 58 59 50\6 16 2 63 64 65\6 66 66 67 68 68 70\7 17 2 73 74 75\6 77 78 78\6 | (15) | | : | | | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | E 2 OF |
| 76 77 78 7980 | (5X) | | | | · | | 76 77 78 79 80 | | 2 |

Amplification of Card Type EX

Card Type EX is the trailer card for the Environmental Generator, and must always appear in the input deck. If no Card Type EN is present, then the default option of zero for wind speed, altitude, and reflection coefficient is used. Upon reading this card, execution control is returned to the GENER8 program.

Card Columns

Description

1-2

"EX" label, indicating the environmental data have been read.

| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|-----------------------|-----------------|---|------------------------------|--|-------------------------------------|----------------------------|
| 1 2 3 | R W | | | | Label | N/A | 123 | FORMAT NUMBER | CARD |
| 4 5 | (12) | | İ | | (Unused Integer) | n/A | 5 | | H |
| 6 7 8 9 10 | (15) | MPRF | 1 to 31 | integer | Weapon Profile number | n/a | 678910 | 5 | RW |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (15) | LEGS | 1,3, or 4 only | integer | Number of legs in the flight path for this Weapon Profile | JWPRF _a (MPRF) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | V 0 | feet/ second | S ₁ , weapon speed along 1st Flight Path Leg | PATHS (JPATH+1) | 16 17 18 19 20 | RAIDGN | Weapon Pro |
| 21 22 23 24 25 | (15) | | > 0 | feet/ second | S ₂ , weapon speed along 2nd Flight path Leg (N/A if LEGS = 1) | PATHS (JPATH+4) | 21 22 23 24 25 | | Weapon Profile Description |
| 26 27 28 29 30 | (15) | | > 0 | feet/ second | S_3 , weapon speed along 3rd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+6) | 26 27 28 29 30 | ROUTINE ROUTINE | ription |
| 27 28 29 30 31 32 33 34 35 | (15) | | > 0 | feet/ second | S_4 , weapon speed along 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+8) | 31323334 35 | WPNGEN | |
| 36 37 38 39 40 | (15) | | ≤ 89 | degrees | θ_1 , absolute value of climb (or dive) angle at beginning of 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+2) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | ≤ 89 | degrees | $\boldsymbol{\theta}_2$, absolute value of climb (or dive) angle at the end of the 2nd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+5) | 41 42 43 44 45 | REMARKS | |
| 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | ≥ 0 | kft | A_1 , cruise altitude reached at the end of the 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+3) | 46 47 48 49 50 51 52 53 54 55 | | |
| (m) | (F10.3) | | 2 0 | kft | A ₂ , cruise altitude reached at the end of the 3rd Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+7) | 56 57 58 59 60 61 62 63 64 65 | JPATH+1 → JWPRF _b (MPRF) | |
| 66 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 7 6 77 78 79 80 | (F10.3) | | ≥ 0 | kft | D, length of the 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+9) | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | MPRF) | PAGE 1 OF |
| 76 77 78 79 BO | (5X) | | | | (Sequence Field) | n/A | 6 77 78 79 80 | | 1 |

Amplification of Card Type RW

| Card Columns | Description |
|--------------|--|
| 1-2 | The label "RW" indicates that this card contains data for a weapon profile. |
| 6-10 | Identification number, MPRF, for this weapon profile. The profile data may be later referenced (on Card Type RAP) by use of this value. |
| 11-15 | The number of legs in the flight path for this weapon profile. Three basic types of profiles are allowed: |
| | One Leg The flight path of a target using a one leg profile consists of a straight line trajectory from launch point to impact point. The only parameter associated with this type of profile is S ₁ , the weapon speed. |
| | Three Leg This is the climb-cruise-dive profile (or dive-cruise-dive, if the cruise altitude specified is lower than the launch altitude). The horizontal projection of this profile is a straight line from launch point to impact point. Parameters associated with the profile are, |
| | s_1 = the speed along the 1st leg |
| | θ_1 = the magnitude of the climb angle along the 1st leg |
| | A ₁ = the cruise altitude for the 2nd leg |
| | S_2 = the speed along the 2nd leg |
| | θ_2 = the magnitude of the dive angle along the 3rd leg |
| | S_3 = the speed along the 3rd leg. |

Card Columns

Description

Four Leg

This is a climb-cruise-dive-cruise profile similar to the three-leg profile except for addition of a terminal cruise leg. The parameters are exactly the same as those for the three-leg profile with the addition of,



A₂ = the altitude at which the final dive-to-cruise transition is made (i.e., the altitude defining the end of leg 3 and the beginning of leg 4).

D = the length of the 4th flight path leg.

For the 3-leg and 4-leg profiles the constant altitude, or 2nd leg is of variable length depending on the launch point to impact point distance, and is thus referred to as the "elastic leg." The angles θ_1 and θ_2 are

specified in magnitude only since the altitude differences to be achieved dictate whether each is a climb or a dive angle.

| 16-20 | s_1 | as | defined | above. |
|-------|-------------------------|----|---------|--------|
| 21-25 | s_2 | ** | 11 | 11 |
| 26-30 | s ₃ | ** | *** | 11 |
| 31-35 | s ₄ | ** | 11 | ** |
| 36-40 | θ_1 | 11 | ** | " |
| 41-45 | $\boldsymbol{\theta_2}$ | 11 | 11 | 11 |
| 46-55 | A 1 | ** | 11 | ** |
| 56-65 | A ₂ | 11 | 11 | 11 |
| 66-75 | D | ** | ** | ** |

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| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
|---|---------|-------|-----------------------------------|----------------|---|--------------------|-------------------------------|--------------------|---------------|
| 11 2 3 | R M | | | | Label | N/A | 12 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A , | 5 | AT 5 | |
| 6 7 8 9 10 | | | : | | | : | 6 7 8 9 10 | ٠ ا | RM |
| 11 12 13 14 15 16 | (15) | | 0 to 1 only | integer | Node data input option 0 - rectangular 1 - cylindrical | N/A | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | NODES | 2 to 15 | integer | Number of nodes in this master flight path | | 16 17 18 19 20 21 | RAIDGN | Master Flight |
| 17 18 19 20 21 22 23 24 25 | (15) | | | | | | 22 23 24 25 | | Path |
| 26 | (15) | | | | | | မ | USING ROUTINE | Header and |
| 31 32 33 34 35 | (15) | | | | | | 3132333435 | MFPGEN | Initial |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 | | Data |
| 41 42 43 44 45 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (F10.3) | | if cylindrical then $Rho_1 \ge 0$ | - | X ₁ coordinate in kft, or Rho ₁ value in kft | PATHS (JPATH+1) | 46 47 48 49 50 51 52 53 54 55 | | |
| | (F10.3) | | | kft or degrees | Y ₁ coordinate in kft, or Theta ₁ value in degrees clockwise from North | PATHS (JPATH+2) | 56 57 58 59 60 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | 0 ح | kft | Z ₁ coordinate in kft | PATHS (JPATH+3) | 66 67 68 69 70 71 72 73 74 75 | | PAGE 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | 2 |

Amplification of Card Type RM

| Card Columns | Description |
|--------------|---|
| 1-2 | The label "RM" indicates that this is a MFP header and initial data card. |
| 6-10 | These card columns are presently unused. |
| 15 | Option number for the MFP node data to follow: |
| | Option 0: rectangular coordinates (X,Y,Z) Option 1: cylindrical coordinates (ρ , θ ,Z). |
| 16-20 | The number of nodes in the MFP being described. At least two nodes are required (for a 1-leg MFP) and up to 15 nodes are permitted. |
| 46-55 | The X (or ρ) coordinate of the 1st node for this MFP. |
| 56-65 | The Y (or θ) coordinate of the 1st node for this MFP. |
| 66-75 | The Z coordinate of the 1st node for this MFP. |

The remainder of the node data for this MFP will be contained on one or more cards (as necessary) of type RMF immediately following. See Card Type RMF for explanation of the input format and method of storage of processed MFP data in the PATHS array.

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|---|---------|-------|-----------------------|----------------|---|------------------------------|---|-------------------|-------------------------|
| 1 2 3 | RMF | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | R | _ |
| 6 7 8 | | | | seconds | Φ , phasing, or time of departure from 1st node | | 6 7 8 9 10 11 12 13 14 15 | 2 READING ROUTINE | RMF |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 38 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 65 57 58 59 50 61 62 63 64 68 66 7 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | kft | X ₂ or Rho ₂ | | 16 17 18 19 20 21 22 23 24 25 | MFPGEN | Master Flight Path Data |
| 26 27 28 29 30 31 32 33 34 35 | (F10.3) | | | kft or degrees | ${	t Y}_2^{}$ or ${	t Theta}_2^{}$ | | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | USING MFPGEN | Data |
| 36 37 38 39 40 41 42 43 44 45 | (F10.3) | | | kft | z_2 | | 36 37 38 39 40 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | > 0 | feet/second | S_{12} , speed at which the target travels between nodes 1 and 2 | | 46 47 48 49 50 51 52 53 54 55 | | |
| 56 57 58 59 50 61 62 63 64 65 | (F10.3) | | • | | (Continue as required on up to eight additional cards, specifying an X,Y,Z,S 4-tuple for each of the MFP nodes) | • | 56 57 58 59 60 61 62 63 64 65 6 | | |
| 66 67 68 69 70 71 72 73 74 75 | (F10.3) | | > 0 | feet/second | S nodes-1,nodes | PATHS (JPATH+ 4*NODES) | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 2 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | 76 77 78 79 80 | | 2 |

Amplification of Card Type RMF

Repeat as many cards of this type (up to 9 cards) to describe all of the nodes for this MFP. Each card must have the letters RMF in columns 1-3. For an MFP having n nodes, there must be n 4-tuples of data as follows:

$$x_1, y_1, z_1, \phi, x_2, y_2, z_2, s_1, z, x_3, y_3, z_3, s_2, s_1, \ldots, x_n, y_n, z_n, s_{n-1,n}$$

or

$$\rho_1, \theta_1, z_1, \phi_2, \theta_2, z_2, s_1, z_1, \rho_3, \theta_3, z_3, s_2, s_1, \ldots, \rho_n, \theta_n, z_n, s_{n-1,n}.$$

The first three of these values will have been included in columns 46-75 of the preceding card of type RM. The parameter Φ is a phasing value which defines the time of departure from the first node for any target using this MFP. Each parameter $S_{i-1,i}$ is the speed at which a target on this MFP travels from node i-1 to node i, for i between 2 and n.

If the cylindrical coordinate option has been selected, the node data will be immediately converted by the program into rectangular coordinates. The length of each MFP leg is then computed as,

$$L_{i-1,i} = \left[\left(x_i - x_{i-1} \right)^2 + \left(y_i - y_{i-1} \right)^2 + \left(z_i - z_{i-1} \right)^2 \right]^{\frac{1}{2}}$$

and the time required to traverse this distance is,

$$\Delta T_{i-1,i} = \frac{L_{i-1,i}}{S_{i-1,i}}.$$

Amplification of Card Type RMF (Concluded)

The time that the target passes through each node is then computed from

$$T_i = T_{i-1} + \Delta T_{i-1,i}, i = 2, \dots, n$$

where

$$T_1 = \Phi$$
.

The processed MFP data are then stored in the PATHS array and later printed out in the input summary in the form,

$$x_1, y_1, z_1, x_1, x_2, y_2, z_2, x_2, \dots, x_n, y_n, z_n, x_n$$

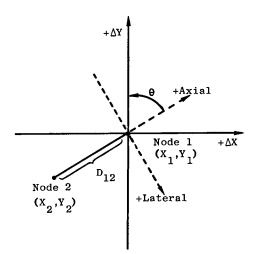
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| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION |] | | |
|--|---------|-------|-----------------------|-------|--|-------------------------------|-----------------|-------------------------|---------------------|
| 11 2 3 | R A | | | Ī | Label | N/A | 1.2 3 | FORMAT NUMBER | CARD |
| [5 | (I2) | | | | (Unused Integer) | N/A | 4 5 | er Er | |
| 6 7 8 9 10 | (15) | | 1 to NTTMAX | | Target Type | JTRGFO _d (JTGT) | 6 7 8 9 10 | 5 | RA |
| 11 12 13 14 15 | (15) | L.ECM | 0 to | | ECM Loading Group number | JTRGFO (JTGT) ^g | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 11 12 13 14 15 16 17 18 19 20 21 | (15) | MPAR | 0 to 15 | | Number of parasites carried | JTRGFO ₁ (JTGT) | 16 17 18 19 20 | RAIDGN | Offense U |
| 21 22 23 24 25 | (15) | | | | | | 21 22 23 24 25 | | Offense Unit Header |
| 26 27 28 29 30 | (15) | | | | | | | ROUTINE | and Data Card |
| 31 32 33 34 35 | (15) | | | | | | 31 32 33 34 36 | ACGEN | Card |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 26 27 28 29 30 01 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (F10.3) | | | kft | Lateral displacement of this target from its MFP (positive value denotes displacement to the right when looking from Node 2 toward Node 1) | See text | 8 | One RA | |
| | (F10.3) | | | | Axial displacement of this target from its MFP (positive value denotes greater range as viewed from Node 2 toward Node 1) | See text | 6 57 58 59 60 6 | A Card per Nonimpacting | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | ĸ | Vertical displacement of this target from its MFP (positive value denotes higher altitude) | DISP (3,JTGT) | 66 67 6 | ting Target | PAGE 1 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | N/A | 576 77 78 79 80 | |)F 2 |

Amplification of Card Type RA

Card Columns Description The label "RA" indicates that this is a nonimpacting 1-2 offense unit card. 6-10 The Target Type number to be associated with this offense unit (refers to a data set defined by Card Type TT within TYPGEN) . 11-15 The ECM Loading Group number to be associated with this offense unit (refers to a data set defined by Card Type TE within TYPGEN). The value 0 is permitted and denotes a nonjamming target. 16-20 The number of parasites, or impacting targets, to be carried by this offense unit. This RA card must be followed directly by one RAP card for each such parasite specified. 46-75 The lateral, axial, and vertical displacements of this offense unit from its MFP (i.e., from the most recently defined MFP). The displacements are relative to the initial leg of the MFP and are as seen from node 2 when looking towards node 1. These values are translated into ΔX , ΔY , and ΔZ values, are stored in the DISP array, and will be subsequently used (in the simulation) as constant

displacements over the entire flight path of this target.



$$D_{12} = \left[\left(x_2 - x_1 \right)^2 + \left(y_2 - y_1 \right)^2 \right]^{\frac{1}{2}}$$

$$\sin \theta = \frac{x_1 - x_2}{D_{12}}$$

$$\cos \theta = \frac{y_1 - y_2}{D_{12}}$$

$$\Delta X = L \cos \theta + A \sin \theta$$

 $\Delta Y = -L \sin \theta + A \cos \theta$ $\Delta Z = Vertical displacement value$

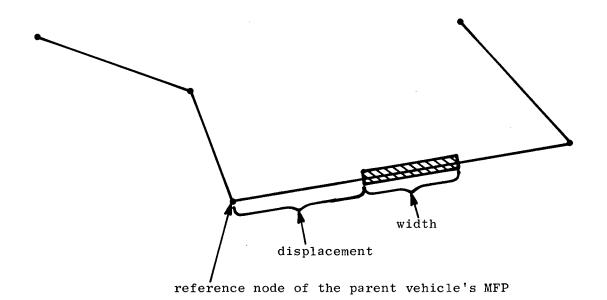
| _ | | | | | | | _ | | |
|--|---------|-------|-----------------------|---------|--|-------------------------------|---|------------------|------------|
| | FORMAT | LABEL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | RAP | | | | Label | N/A | 1 2 3 | FORMAT | CARD |
| 5 | (12) | | | | (Unused Integer) | N/A | 5 | ŖΑ | |
| 6 7 8 9 10 | (15) | NTYP | 1 to NTTMAX | | Target Type | JTRGFO _d (JTGT) | 6 7 8 9 10 | 5 | RAP |
| 11 12 13 14 15 16 | (15) | | 1 to NECMAX | | ECM Loading Group number | JTRGFO _g (JTGT) | 11 12 13 14 15 | RE ADING | PURPOSE |
| 16 17 18 19 20 | (15) | IWPF | 1 to 31 | integer | Weapon Profile number to be used by this target | JTRGFO _k (JTGT) | 16 17 18 19 20 | CGEN | Parasite I |
| 17 18 19 20 21 22 23 24 25 | (15) | | 1 to ISMAX | integer | Defense Unit being attacked by this target | JTRGFO _h (JTGT) | 21 22 23 24 25 | | Data Card |
| 26 27 28 29 30 | (15) | | 1 to NODES | integer | Launch vehicle node from which parasite launch is determined | JTRGFO ₁ (JTGT) | 26 27 28 29 30 | HOUTINE DNISU | |
| 27 28 29 30 31 32 33 34 35 | (15) | | 0 to 255 | seconds | Displacement of launch interval from launch reference node | JTRGFO _m (JTGT) | 31 32 33 34 35 | ACGEN | |
| 36 37 38 39 40 | (15) | | 0 to 15 | seconds | Launch interval width | JTRGFO _n (JTGT) | 36 37 38 39 40 | | |
| 41 42 43 44 46 | (15) | | 0 or 1 only | integer | Deterministic aim point indicator | JTRGFO _q (JTGT) | 41 42 43 44 45 | REMARKS | |
| 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | x ≤ 500 | feet | Deterministic aim point x coordinate if applicable | JTRGFO _r | 46 47 48 49 50 51 52 53 54 55 | RAP Card per | |
| ý. | | | y ≤ 500 | feet | Deterministic aim point y coordinate if applicable | JTRGFO _S (JTGT) | 56 57 58 59 60 61 62 63 64 65 | | |
| 56 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | z ≤ 500 | feet | Deterministic aim point z coordinate if applicable | JTRGFO _t (JTGT) | 06 6/ 68 69 /0 // // /3/4/5/6 // /8 /9 80 | | PAGE 2: OF |
| 5 76 77 78 7980 | (5X) | | | | (Sequence Field) | N/A | /6 // /0 /9 00 | | F 2 |

Amplification of Card Type RAP

| Card Columns | Description |
|--------------|--|
| 1-3 | The label "RAP" indicates that this is an impacting offense unit card. |
| 6-10 | The Target Type number to be associated with this offense unit (refers to a data set defined by Card Type TT within TYPGEN). |
| 11-15 | The ECM Loading Group number to be associated with this offense unit (refers to a data set defined by Card Type TE within TYPGEN). The value 0 is permitted and denotes a nonjamming target. |
| 16-20 | The Weapon Profile number to be used by this impacting target (refers to a data set defined by Card Type RW within RAIDGN). The exact launch point will be determined at the beginning of each replication based upon a random displacement from a specified node (see columns 26-40) of the parent, or launch vehicle. The exact impact point will also be determined at the beginning of each replication based upon a random dispersion about the defense unit under attack (see columns 21-25) as derived from the delivery accuracies associated with the Target Type of this offense unit (impact dispersion about the aim point) and with the Target Type of the parent launch vehicle (aim point dispersion about the victim defense unit's position). |
| 21-25 | Identification number of the defense unit under attack and against which damage assessment will be made if impact occurs. |
| 26-30 | The MFP node of the parent launch vehicle with respect to which the beginning of the random launch interval is to be displaced in time. |

Amplification of Card Type RAP, Continued

| Card Columns | Description |
|--------------|--|
| 31-35 | The time displacement of the beginning of the launch interval from the MFP node defined in columns 26-30. |
| 36-40 | The time width of the launch interval for this impacting target. Launch of this target will occur according to a uniform probability distribution within the time interval so defined and illustrated below. The launch interval must be entirely contained within the period of activation of the launch vehicle (i.e., between the time of departure from the first MFP node and the time of arrival at the final MFP node). |



Amplification of Card Type RAP, continued

| Card Columns | Description |
|--------------|--|
| 41-45 | Deterministic aim point indicator; zero (0) if aim point is to be calculated by the program*, and one (1) if a deterministic aim point is given below. |
| 46-55 | X - coordinate of deterministic aim point, expressed in feet**; zero or blank otherwise. |
| 56-65 | Y - coordinate of deterministic aim point, expressed in feet**; zero or blank otherwise. |
| 66-75 | <pre>z - coordinate of deterministic air point, expressed in feet**; zero or blank otherwise.</pre> |

^{*}Program assumes aim point uniformly distributed over ship.

^{**}Note that $|x| \le 500$, $|y| \le 500$, $|z| \le 500$.

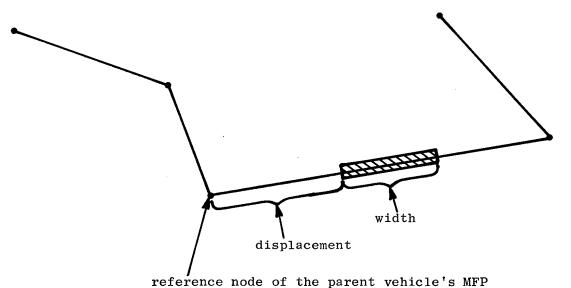
| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|-----------------------|---------|---|-------------------------------|--|--------------------|--------------------|
| 11 2 3 | RAP | | | | Label | N/A | 1 2 3 | FORMAT | CARD NAME |
| 6 | (12) | | | | (Unused Integer) | N/A | 4 5 | 뜻극 | _ |
| 6 7 8 9 10 | (15) | NTYP | 1 to NTIMAX | | Target Type | JTRGFO _d (JTGT) | 6 7 8 9 10 | 5 | RAP |
| 11 12 13 14 15 | (15) | | 1 to NECMAX | | ECM Loading Group number | JTRGFO (JTGT) | . 6 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | IWPF | 1 to 31 | integer | Weapon Profile number to be used by this target | JTRGFO _k (JTGT) | 16 17 18 19 20 | ACGEN | Parasite Data Card |
| 18 19 20 21 22 23 24 25 | (15) | | 1 to ISMAX | integer | Defense Unit against which this target will actually impact | JTRGFO _h (JTGT) | 21 22 23 24 25 | | Data Card |
| 26 27 28 29 30 | (15) | | 1 to NODES | integer | Launch vehicle node from which parasite launch is determined | JTRGFO ₁ (JTGT) | 18 | ROUTINE | |
| 31 32 33 34 35 | (15) | | 0 to 255 | seconds | Displacement of launch interval from launch reference node | JTRGFO _m (JTGT) | 31323334 35 | ACGEN | |
| 36 37 38 39 40 | (15) | | 0 to 15 | seconds | Launch interval width | JTRGFO _n (JTGT) | 36 37 38 39 40 41 42 43 44 45 | | |
| 41 42 43 44 45 | (15) | | 1 to ISMAX | integer | Defense Unit against which this target intends to impact (See also columns 21-25 above) | JTRGFO (JTGT) | 11 42 43 44 45 | REMARKS | |
| 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | 0 to 1.0 | real | Prelaunch failure probability | JTFAIL _a (JTGT) | 46 47 48 49 50 51 52 53 54 55 | One RAP Card per I | |
| 56 57 58 59 60 61 62 63 64 66 | (F10.3) | | 0 to 1.0 | real | Inflight failure probability | JTFAIL _b (JTGT) | 56 57 58 59 60 61 62 63 64 65 | mpacting Target | ; |
| 56 57 58 59 50 61 62 63 64 66 66 67 68 69 70 71 72 73 74 75 7 6 77 78 79 80 | (F10.3) | | 0 to 1.0 | real | Detonation failure probability | JTFAIL _C (JTGT) | 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 2 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | 2 |

Amplification of Card Type RAP*

| Card Columns | Description |
|--------------|--|
| 1-3 | The label "RAP" indicates that this is an impacting offense unit card. |
| 6-10 | The Target Type number to be associated with this offense unit (refers to a data set defined by Card Type TT within TYPGEN). |
| 11-15 | The ECM Loading Group number to be associated with this offense unit (refers to a data set defined by Card Type TE within TYPGEN). The value 0 is permitted and denotes a nonjamming target. |
| 16-20 | The Weapon Profile number to be used by this impacting target (refers to a data set defined by Card Type RW within RAIDGN). The exact launch point will be determined at the beginning of each replication based upon a random displacement from a specified node (see columns 26-40) of the parent, or launch vehicle. The exact impact point will also be determined at the beginning of each replication based upon a random dispersion about the defense unit under attack (see columns 21-25) as derived from the delivery accuracies associated with the Target Type of this offense unit (impact dispersion about the aim point) and with the Target Type of the parent launch vehicle (aim point dispersion about the victim defense unit's position). |
| 21-25 | Identification number of the defense unit against which damage assessment will be made if impact occurs. |
| 26-30 | The MFP node of the parent launch vehicle with respect to which the beginning of the random launch interval is to be displaced in time. |

^{*}This card is a modification of the foregoing RAP card to be used in the TDHS version of the model. Entries unique to the TDHS are written in italics.

The time displacement of the beginning of the launch interval from the MFP node defined in columns 26-30. The time width of the launch interval for this impacting target. Launch of this target will occur according to a uniform probability distribution within the time interval so defined and illustrated below. The launch interval must be entirely contained within the period of activation of the launch vehicle (i.e., between the time of departure from the first MFP node and the time of arrival at the final MFP node).



| | • |
|-------|---|
| 41-45 | Identification number of the defense unit against which an attack was intended. |
| 46-55 | The probability that the parent vehicle will fail to successfully launch this impacting target. |
| 56-65 | The probability that this impacting target will experience an inflight failure. |
| 66-75 | The probability that this impacting target will fail to detonate upon impact. |

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| | FORMAT | LABEL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|-----------------------|-------|------------------|-------------|---|------------------------|--------------------|
| 1 2 3 | RХ | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | n/a | 5 | AT 5 | |
| 678910 | (15) | | | | | | 6 7 8 9 10 | | RX |
| 11 12 13 14 15 | (15) | | | | | | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | | | | | | 16 17 18 19 20 | RAIDGN | Trailer Card |
| 21 22 23 24 25 | (15) | | | | | | 21 22 23 24 25 2 | | for |
| 26 27 28 29 30 | (15) | | | | | | 6 27 28 29 30 | USING ROUTINE | the Raid Generator |
| 31 32 33 34 35 | (15) | | | | | | 11323334 353 | RAIDGN | rator |
| 36 37 38 39 40 | (15) | | | | | | 6 37 38 39 40 4 | | |
| 41 42 43 44 45 | (15) | | | | | | 1 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 51 52 53 54 55 | (F10.3) | | | | | | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 56 57 58 59 50 61 62 63 64 65 | (F10.3) | | | | | | 56 57 58 59 60 61 62 63 64 65 | Terminates Raid Inputs | |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 56 56 56 56 56 56 56 66 67 58 68 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | ıputs | PAGE 1 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | 1 |

Amplification of Card Type RX

Card Columns Description

1-2

The label "RX" indicates that all inputs to the Raid Generator have been read. This card causes return of execution control to the GENER8 program which will then cause printing of the input summary listing for the TYPGEN, DEFGEN, and RAIDGN data.

Appendix B

PACKED LIST FORMATS

Appendix B

PACKED LIST FORMATS

A general purpose bit packing (and unpacking) routine called PUTBIT (GETBIT) has been written and is used extensively throughout the simulation model. With this FORTRAN callable routine, individual bits or groups of bits may be accessed and modified within various arrays of packed words. A completely arbitrary number of bits may be allocated per unit within each list, depending only on the amount of information to be packed. There are presently 43 such lists, including those unique to the TDHS version of the model as indicated by italics, defined as shown in Table B-1.

The product of the number of bits per unit and the maximum number of such units to be accommodated determines the total number of bits required in each packed list. The dimension (in machine words) to be compiled for each list is then established by dividing the total number of bits required by the number of bits per word in the machine being used, increasing any fractional part to the next higher integer. The column in Table B-1 labeled "Total Bits" and subheaded "Full" and "Reduced" contains the total number of bits required by the packed lists for each of two configurations of the model as described in Appendix C. Briefly, the full configuration gives all arrays and packed lists their maximum allowable dimensions, thus allowing full task-force

runs with large raids. The reduced configuration limits the size of many arrays and packed lists below their maximum dimensions to allow smaller and simpler runs to be made at lower computer cost.

The packing format for each of the 43 lists shown in

Table B-1 is presented in the remainder of this appendix. The

list dimensions (item E) are given for 60 and 36 bit machine

word lengths. In order to facilitate possible future modifications

to the packed lists, the number of bits per unit is assigned

a mnemonic for each list and the name of the common block

containing each list is shown (item A).

In some cases the packed list fields may be slightly larger than actually required (e.g., field b in the ISHPFO list is 6 bits wide but need be only 5 bits wide to accommodate its full range of values). This has been done in order to obtain a number of equal width adjacent fields since any number of such contiguous, equal width fields may be manipulated with a single call to the PUTBIT/GETBIT subroutine.

Table B1 - Packed Lists

| | Unit | Bits per | Tota | l Bits | Page |
|------------|--------------------------------------|----------|----------|-------------|----------|
| List Name | UIIL | Unit | Fu11 | Reduced | Number |
| IBOLFN | Boolean function | 25 | 15500 | 3500 | B- 4 |
| IBOLV | Boolean-function variable | 8 | 24800 | 5600 | B- 5 |
| COMM | Ship | ISMAX | 961 | 49 | в- 6 |
| COMPO | Component | 12 | 7440 | 1680 | B- 7 |
| ICOPER | Tracking operator (TDHS) | 40 | 280 | 280 | в- 8 |
| TTPAR | Component Type | 183 | 36600 | 18300 | в- 9 |
| DETPC | Radar set | 2*JTMAX | 32130 | 1890 | в-10 |
| IMODIF | Ship | ISMAX | 961 | 49 | в-11 |
| IRADPC | Radar set | 30 | 1190 | 450 | B-12 |
| RADPC* | Radar set (IRADPC modified for TDHS) | 30 | 1190 | 450 | в-13 |
| RDRPC | Radar type | 35 | 1085 | 1085 | B-14 |
| IRDROP | Radar type | 84 | 2724 | 2724 | в-15 |
| SHPFO | Ship | 93 | 2883 | 65 1 | в-16 |
| TRSUP | Ship (TDHS) | 57 | | 399 | B-17 |
| JGCGRP | Guidance-channel group | 30 | 1890 | 450 | в-18 |
| #REPRT | Track (TDHS) | 48 | | 3024 | B-19 |
| TFAIL | Target (TDHS) | 21 | | 1323 | в-20 |
| JTØUT | Target | 42 | 10710 | 2646 | B-21 |
| JTRGFO | Target | 106 | 27030 | 6678 | B-22 |
| VPRF | Weapon profile | 15 | 465 | 465 | в-23 |
| GCA | Guidance-channel constraint-group | 384 | 5760 | 5760 | B-24 |
| 220011 | type | | | | · |
| EPC | Guidance-channel constraint-group | 128 | 1920 | 1920 | B-25 |
| | type | | | | 1 |
| KGUID | Guidance channel | 44 | 11220 | 2772 | в-26 |
| KRSHPT | Ship type | 35 | 1085 | 1085 | В-27 |
| TSHPT | Ship type (TDHS) | 70 | | 490 | В-28 |
| LAUNFO | Launcher | 66 | 4185 | 990 | B-29 |
| LCHPAR | Launcher type | 38 | 570 | 570 | в-30 |
| NSHPT | Ship type | 315 | 9765 | 9765 | в-31 |
| SLPAR | Missile type | 36 | 540 | 540 | в-32 |
| MSLPK | Missile type | 315 | 4725 | 4725 | в-33 |
| BOVAR | Ship-type component | 8 | 4960 | 1120 | в-34 |
| CCCDT | Component | 75 | 46500 | 10500 | B-35 |
| NCSGRP | Cross-section group | 14 | 210 | 210 | в-36 |
| NECMGP | ECM loading group | 53 | 795 | 795 | в-37 |
| GCSTYP | Guidance-channel constraint-group | 14 | 210 | 210 | В-38 |
| | type | | | 1 | |
| NONOFF | Component | 44 | 27280 | 5280 | в-39 |
| PSHPT | Ship type | 38 | 1178 | 1178 | B-40 |
| SPGO | Entry* | 10 | 11780 | 2660 | B-41 |
| NSTCOM | Ship-type component | 73 | 45260 | 10220 | B-42 |
| TGPAR | Target type | 88 | 1320 | 1320 | в-43 |
| rrho | Component | 100 | 62000 | 14000 | B-44 |
| NUDOOF | Component | 2 | 1240 | 280 | B-45 |
| NVSHPT | Ship type | 300 | 9300 | 9300 | B-46 |
| | - 1 71 | <u> </u> | <u> </u> | 1 | <u> </u> |

See description of packed list NSPGO

| ne pac | ked grou | p per | Boolean function of which t | here may be_ | 620 |
|---------|------------------|----------------|--|--------------|-------|
| Packing | Format: | | | | |
| Field | First Bit. No | Field Width | Purpose | Re | marks |
| а | 1 | 8 | function number | | |
| Ъ | 9 | 8 | beginning location of variables in IBOLV | , | |
| С | 17 | 8 | no. of variables | | ٠ |
| d | 25 | 1 | and (0)/or (1) indicator | | |
| | | | | | |
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| | | | | | |
| its pe | r unit | 25 | Total packed list length 155 | 500 | bits. |
| - | | on macl | nine with word length of: | | |
| | | | words; 36 bits 431 words; bits | WO | _ |

| A. | Packed list name | IBOLV | , BPU | name _ | IBV | Common b | lock name | BOOL |
|----|------------------|-------|------------|-----------|------------|-----------|-----------|------|
| В. | One packed group | per | Boolean fu | nction va | ariable of | which the | re may be | 3100 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|---------------------------|---|
| a | 1 | 8 | Boolean function variable | referenced by field b in IBOLFN for each Boolean functi |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| D. | Bits | per unit | 8 | Total | packed | list | 1ength | 24,800 | bits. |
|----|------|-----------|---------------|----------|----------|------|--------|--------|-------|
| E. | List | dimension | on machine wi | ith word | l length | of: | | | |

60 bits 414 words; 36 bits 689 words; bits words

| One p | acked gr | oup per | Ship (Receiver) of which the | ere may be31 |
|-------|---------------------|----------------|--|--------------------|
| Packi | ng Forma | t: | | • |
| Field | First Bit No. | Field Width | Purpose | Remarks |
| а | 1 | 1 | The ship can (0) or cannot (1) receive communications transmissions from ship 1 | |
| b | 2 | 1 | from ship 2 | |
| : | : | : | | |
| - | 31 | 1 | from ship 31 | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | , |
| | | | | |
| | | | , | |
| Bits | per unit | 31 | . Total packed list length 9 |)61 bits. |
| | | | achine with word length of: | |
| 60 | bits | 17 | words; 36 bits 31 words; bits | words |
| Notes | : | | | |
| | paramet t as fol | | T, also in common block TECOMM, may overri | de this packed |
| I | XMIT < 0 | | s that no communications links exist (and modified). | further, that none |
| I | XMIT = O | implie | s that some links exist as specified in the and further that some, all, or none may be | |

none may be modified).

IXMIT > 0 implies that all communications links exist (and further, that

specified by MODIFY and IMODIF, also in common block TECOMM).

| A. | Packed list name | ICOMPO | BPU name | IBI | Common block r | name | COMPON . |
|----|------------------|------------|----------|------|-----------------|------|----------|
| ъ | One neeked aroun | nor Compon | ent | of s | which there may | z be | 620 |

| Field | First Bit. No. | Field Width | Purpose | Remarks |
|--------|-------------------|----------------|---|---|
| a b | 7 | 6 | System code (Radar, Guidance Channel, or Launcher), if applicable Unit Number assigned in DEFGEN, if applicable | "O" otherwise Note #1 "O" otherwise |
| ٠. | | | | |
| | | | | |
| | | | · | |
| | | | | |

| D. | Bits per unit | <u>12</u> . | Total packed | list length | 7440 | bits. |
|----|----------------|-------------|--------------|-------------|------|-------|
| E. | List dimension | | | | | |
| | 60 bits | 124 word | s; 36 bits | 7 words; | bits | words |
| _ | | | | | | |

F. Notes:

#1 System Codes:
 Radar = 1
 Guidance Channe1 = 2
 Launcher = 3
 Other = 0

| acking | Format: | | | |
|--------|------------------|----------------|---|---------|
| ?ield | First Bit. No | Field Width | Purpose | Remarks |
| а | 1 | 1 | Active (1) or inactive (0) | |
| b | 2 | 6 | Task force radar number to which this operator is assigned | |
| c | 8 | 1 | (1) if the operator is in automatic offset mode, (0) if not | |
| d | 9 | 7 | The track supervisor number associated with this operator | |
| e | 16 | 15 | Scope limit for the operator | kft |
| f | 31 | 10 | Ball tab error for this operator in thousandths of an inch | |
| | | ; | | |
| | | | | |
| ts pe | r unit | 40 | . Total packed list length _ 280 | bits. |

| A. | Packed list name | ICTPAR | BPU name | IBITS8 . Comm | on block name | COMPON |
|----|------------------|---------------|----------|---------------|---------------|--------|
| B. | One packed group | per Component | t Type | of which | there may be | 200 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|---|---------------------------|
| a | a 1 | | 01d (0) or new (1) data | |
| Ъ | 2 | 1 | Good (0) or bad (1) data | |
| c | 3 | 20 | Expected time between failures (seconds) | In units of Q4Q1 $^{\#1}$ |
| đ | 23 | 20 | Replacement cost (dollars) | In units of Q4Q2 |
| е | 43 | 10 | $E[R] \times 1000$ for vulnerability | |
| £ | 53 | 10 | $k \times 1000$ for variance of R | |
| g | 63 | 10 | E[R] x 1000 for failure | |
| h | 73 | 20 | Expected repair delay time | minutes |
| i | 93 | 20 | Expected time to die | seconds |
| j | 113 | 20 | Standard deviation of time to die | seconds |
| k | 133 | 20 | Expected repair rate | dollars/hr |
| 1 | 153 | 20 | Standard deviation of repair rate | dollars/hr |
| m | 173 | 10 | Reference peak overpressure | lbs/sq. inch |
| π | 183 | 1 | Undefined (0) or defined (1) component type | #2 |

| D. | Bits per unit | . Total | packed | list length | 36600 | bits |
|----|---------------|-------------|--------|-------------|-------|------|

| 60 bits | 610 | words; 36 | bits | 1017 | words: | bits | words |
|-------------|-----|-----------|------|------|---------------------------------------|------|-------|
| | | | | | · · · · · · · · · · · · · · · · · · · | | |

E. List dimension on machine with word length of:

F. Notes:

 $^{^{\#1}\}mathrm{Q4Q1}$ and Q4Q2 are storage scaling factors set in INITLZ.

 $^{^{\}sharp2}$ Fields a through m may be 0 even though component type is defined.

| А. В. С. | One p | | oup per | DETPC BPU name IBITS1 Common by Radar Set of which there | |
|----------------|-------|------|---------|--|-------------|
| ·. | · | | Field | Purpose | Remarks |
| | a | 1 | 1 | Primary detection status of target 1 w.r.t. this radar set | Note #1 |
| | b | 2 | 1 | Secondary detection status of target 1 w.r.t. this radar set | Note #1 |
| | | • | : | | |
| | _ | 21-1 | 1 | Primary detection status of target i w.r.t. this radar set | |
| | _ | 2i | 1 | Secondary detection status of target i w.r.t. this radar set | |
| | | | | | |
|). | | | | Total packed list length 32,130 | bits. |
| s. r. | | | | chine with word length of: words; 36 bits 893 words; bits | words |

#1. 0 implies nondetected, 1 implies detected.

| A. B. | | | | MODIF . BPU name IBITS7 . Common Ship (Receiver) of which ther | block name TECOMM C |
|----------|--------|------------------|----------------|--|---------------------|
| c. | Packi | ng Forma | \$ 5 | | |
| | Field | First Bit No. | Field Width | Purpose | Remarks |
| | a | 1 | | The communication link status from ship l to this ship can (0) or cannot (1) be modified by enemy jamming action | |
| | b | 2 ' | 1 | from ship 2 to this ship | |
| | | • | : | | |
| | _ | 31 | 1 | from ship 31 to this ship | |
| | | | | | |
| | | · | | | |
| Į | | | | | |
| D. E. | List d | | on ma | . Total packed list length 96 chine with word length of: words; 36 bits 31 words; bits | |
| F. | Notes: | | | | |
| | note | for pac | ked li | er IXMIT equals 0, this packed list is ignorst ICOMM). The parameter MODIFY, also in capacked list as follows: | |
| | | |) impli | es that no links may be modified. es that only the links specified in the pace) e) may be modified. | ked list IMODIF |

 ${\tt MODIFY} > 0$ implies that all links may be modified.

| Α. | Packed list name | IRADPC . BP | U nameIBITS2 | Comm | on block name | RADAR |
|----|------------------|---------------|--------------|----------|----------------|-------|
| В. | One packed group | per Radar Set | | of which | there may be _ | 63 . |

| Field | First Bit No. | Field Width | | Remarks |
|-------|------------------|----------------|------------------------------------|---------|
| a | 1 | 1 | Disabled (1) or not (0) | |
| b | 2 | 1 | Activated (1) or not (0) | Note #1 |
| с | 3 | 4 | Radar simulation model option | Note #2 |
| d | 7 | 6 | Radar type number | |
| е | 13 | 6 | Associated ship number | |
| f | 19 | 2x6 | No. of primary detections achieved | |
| | | | | |

| D. | Bits per unit | 30 | Total pac | ked list l | ength | 1,890 | bits. |
|----|-------------------|-------------|-----------|------------|---------|-------|-------|
| E. | List dimension or | n machine v | with word | length of: | | | |
| | 60 bits 32 | words; | 36 bits | 53w | ords; l | oits | words |
| F. | Notes: | | | | | | |

- #1. Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.
- #2. Fields a, b, and c would normally be picked up together as a single6 bit field, with a value greater than 31 implying a disabled radar set.

| A. | Packed list name | IRADPC* | BPU name | IBITS2 . C | common block name | me RADAR |
|----|------------------|---------|-----------|------------|-------------------|----------|
| В. | One packed group | perF | Radar Set | of wh | ich there may | be63 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|-------------------------------|---------------------------|
| а | 1 | 1 | Disabled (1) or not (0) | |
| ь | 2 | 1 | Activated (1) or not (0) | Note #1 |
| c | 3 | 4 | Radar simulation model option | Note #2 |
| đ | 7 | 6 | Radar type number | |
| 6 | 13 | 6 | Associated ship number | |
| f | 19 | 6 | Sigma of range error | range resolution cells |
| g | 25 | 6 | Sigma of azimuth error | mils |
| | | | | |
| | | | | |

| D. | Bits per ur | it <u>30</u> | , | Total | packed | list | length | 1,890 | bits |
|----|-------------|--------------|---|-------|--------|------|--------|-------|------|
|----|-------------|--------------|---|-------|--------|------|--------|-------|------|

E. List dimension on machine with word length of:

| 60 | bits | 32 | words; 36 | bits | 53 | words; | bits | word |
|----|------|----|-----------|------|----|--------|------|------|
| | .= | | | | | · — | | |

F. Notes:

 $^{^{\#1}}$ Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.

 $^{^{\#2}{\}rm Fields}$ a, b, and c would normally be picked up together as a single 6 bit field, with a value greater than 31 implying a disabled radar set.

 $^{^{*}}$ IRADPC packed list format for TDHS version.

| | | | RDRPC . BPU name IBITS3 . Common | |
|-----------|------------------|----------------|--|--------------|
| One pa | acked gro | oup per | Radar Type of which then | re may be 31 |
| Packir | ng Forma | t: | | |
| Field | First Bit No. | Field Width | Purpose | Remarks |
| а | 1 | 1 | Old (0) or new (1) type data | |
| b | 2 | 1 | Good (0) or bad (1) type data | Note #1 |
| С | 3 | 3 | Radar frequency band index | |
| đ | 6 | 5 | Target acquisition delay for tracking radars | seconds |
| е | 11 | 5 | Kill evaluation delay for tracking radars | 11 |
| f | 16 | 5 | Surveillance radar scan rate | 11 |
| g | 21 | 3x5 | Maximum unambiguous range | kft |
| | E. | | | |
| | 4 6. | | | |
| | | | | |
| | | | | |
| | | | · | |
| | | | | |
| | | | | |
| | | | | |
| Bits | per unit | 35 | Total packed list length 1,085 | bits. |
| List | dimensio | n on ma | achine with word length of: | |
| <u>60</u> | bits | 19 | words; <u>36</u> bits <u>31</u> words; <u>bits</u> | words |
| Notes: | | | | |

#1. These three fields together constitute a single 5 bit field during the play of the game (at which time fields a and b should both be zero).

| Α. | Packed list nar | ne IRDROP. | BPU name | IBITS4. | Common | block nam | ne <u>RADAR</u> |
|----|-----------------|---------------------|----------|---------|------------|-----------|-----------------|
| В. | One packed gro | up per <u>Radar</u> | Туре | of | which ther | re may be | 31 |

| С. | Packing | Earmot. |
|----|---------|----------|
| | PACKINS | rormat.: |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|---|---------|
| а | 1 | 6 | Radar wavelength in centimeters. | |
| b | 7 | 6 | Receiver IF noise bandwidth in megahertz. | |
| с | 13 | 6 | Transmitter antenna gain in db. | |
| d | 19 | 6 | Receiver antenna gain in db. | |
| е | 25 | 6 | Sidelobe level in db down from the receiver main beam. | |
| f | 31 | 6 | Transmitter losses in db. | |
| g | 37 | 6 | Receiver losses in db. | |
| h | 43 | 6 | Receiver noise figure in db. | |
| i | 49 | 6 | Number of pulses integrated. | |
| j | 55 | 6 | False alarm probability factor, a, where $a = -\log_{10}P_{fa}$ | |
| k | 61 | 6 | Horizontal antenna pattern function index. | Note #1 |
| 1 | 67 | 6 | Vertical antenna pattern function index. | Note #1 |
| m | 73 | 6 | Constraint applicability. | Note #2 |
| n | 79 | 6 | Resolution applicability. | Note #3 |
| | | | · | |

| D, | Bits per | unit | 84 | Total | packed | list | length | 2,724 | bits. |
|-----|-----------|------|----|-------|--------|------|--------|-------|-------|
| - • | 210,5 PU- | | | | P | | | | |

| F. | Lict | dimension | on | machina | with | word | langth | of. |
|----|------|-----------|-----|---------|------|-------|-----------------|--------|
| ٠. | பாதர | urmension | UII | machine | WICH | wor-a | 1 14 11 12 1.11 | () 1 : |

| 60 | bits | 45 | words; | 36 | bits | 7 6 | words; | bits | words |
|----|------|----|--------|----|------|------------|--------|------|-------|
| | | | • | | | | | | |

- #1. 0 Pencil Beam $\{(\sin x)/x\}$
- #2. Contains 4*gc + 2*rc + pc (see Card Type TRI)
- #3. Contains 16*sr + 8*rr + 4*hr + 2*vr + pr (see Card Type TRI)

| Α. | Packed list name | ISHPFO . | BPU name <u>IBITS5</u> . | Common block | name SHIP. |
|----|------------------|----------|--------------------------|-----------------|----------------|
| В. | One packed group | per Ship | of | which there may | be <u>31</u> . |

| C. | Packing | Format: |
|----|---------|---------|
| | | |

| Field | | Field Width | Purpose | Remarks |
|-------|----|----------------|---|--------------------------|
| а | 1 | 1 | Active (0) or disabled (1) | Note #1 |
| b | 2 | 5 | Ship type | |
| С | 7 | 6 | TEWA group number | ≤ 31 |
| d | 13 | 6 | First scanning radar set number associated with this ship | cross reference |
| e | 19 | 6 | Total number of scanning radar sets associated with this ship | ≤ 7 |
| f | 25 | 6 | First launcher number associated with this ship | cross reference |
| g | 31 | 6 | Total number of launchers associated with this ship | ≤ 15 |
| h | 37 | 6 | First guidance channel group number associated with this ship | cross reference |
| i | 43 | 6 | Total number of guidance channel groups associated with this ship | ≤ 7 |
| j | 49 | 9 | First guidance channel number associated with this ship | cross reference |
| k | 58 | 9 | Total number of guidance channels associated with this ship | ≤ 63 |
| 1 | 67 | 9 | Ship heading | degrees CW from North |
| m | 76 | 9 | Intended impacts against this ship | |
| n | 85 | 9 | Impacts experienced by this ship | |
| | | | | |

| D. | Bits per unit | 93. | Total packed 1: | ist length _ | 2,883 | bits. | |
|----|----------------|------------|--------------------|--------------|-------|-------|--|
| Ε. | List dimension | on machine | with word length | h of: | | | |
| | <u>60</u> bits | 49 words | ; <u>36</u> bits81 | words; | bits | words | |
| F | Notes: | | | | | | |

#1. "Disabled" implies that no radar or launcher/guidance channel combination is available for use for the remainder of the game replication.

| A. | Packed list name | ITRSUP . | BPU name | IBITS9 . Com | mon block name | CONSOL . |
|----|------------------|----------|----------|--------------|----------------|----------|
| R. | One packed group | per | Ship | of whic | h there may be | 7. |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|---|---------|
| а | 1 | 1 | Active (1) or inactive (0) | |
| b | 2 | 7 | Radar number assigned to the track supervosor | |
| c | 9 | 8 | First tracking operator number assigned to this track supervisor | |
| d | 17 | 8 | Last tracking operator number assigned to this track supervisor | |
| e | 25 | 8 | The number of currently active tracking operators assigned to this track supervisor | |
| f | 33 | 15 | Scope limit for the track supervisor | kft |
| g | 48 | 10 | Ball tab error for the track supervisor in thousandths of an inch | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| D. | Bits | per | unit | 57 | · ˈ | Total | packed | list | length | | 399 | <u> </u> | bits. | |
|----|------|-----------|--------|---------|----------|--------------|----------|------|--------|---------------|------|----------|-------|--|
| E. | List | dim | ension | on mach | ine with | h word | l length | of: | | | | | | |
| | | <u>60</u> | bits | 7 | words; | <u>36</u> bi | ts | 12 | words; | . | bits | | words | |

| - | Packed list name | | BPU nameJBITS1 | | | | | GUIDCH | |
|----|------------------|---------------------|----------------|----|-------------|-----|----|--------|---|
| в. | One packed group | per <u>Guidance</u> | Channel Group* | of | which there | may | ъе | 63 | • |
| c. | Packing Format: | | | | | • | | | |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--|-----------------|
| а | 1 | 2x5 | First guidance channel number belonging to this group | |
| b | 11 | 5 | Total number of currently active guidance channels belonging to this group | Note #1 |
| С | 16 | 5 | Guidance channel group type | ≤ 15 |
| d | 21 | 5 | Radar simulation model option | |
| е | 26 | 5 | Parent ship number | Cross reference |
| | | | | |
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| D. | Bits per unit 30. Total packed list length | 1890 | bits. |
|----|--|------|-------|
| E. | List dimension on machine with word length of: | | |
| | 60 bits 32 words; 36 bits 53 words; | bits | words |
| F. | Notes: | | |

#1. May be reduced as ship damage is inflicted.

^{*} Supplemented by constraint arrays associated with the guidance channel group type and by acquisition and kill evaluation delay times associated with the tracking radar type.

| A. | Packed list name | JREPRT . | BPU name | JBITS6 . | Common 1 | block name | TRACK |
|----|------------------|----------|----------|----------|-----------|------------|-------|
| В. | One packed group | per | Track | of | which the | ere may be | 63 |

| | Format: First Bit. No | Field | Purpose | Remarks |
|---|-----------------------------|-------|--|---------|
| а | 1 | 8 | Reporting radar for most recent report | |
| b | .9 | 8 | Tracking operator for most recent report | |
| c | 17 | 8 | The number of valid entries in the array REPRTS for this track | ≤ 5 |
| d | 25 | 8 | The number of consecutive missed reports | |
| e | 33 | 8 | The total number of updates performed | |
| f | 41 | 8 | The total number of missed reports | |
| | | | | |
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| D. | Bits | pe | r unit | 48 | · ' | [otal | packed | list | length | 3024 | bits. |
|----|------|-----|---------|---------|---------|--------------|--------|------|--------|------|-------|
| E. | List | di | mension | on mach | ine wit | n word | length | of: | | | |
| | | 60_ | bits_ | 51 | words; | 36 bi | .ts8 | 34 | words; | bits | words |

| _ | ked grou | | Target of which there | may be 63 |
|-------|------------------|----------------|--|--------------------|
| cking | Format: | · | | |
| ield | First Bit. No | Field Width | Purpose | Remarks |
| а | 1 | 7 | The probability (stored as a percent) that the parent vehicle fails to launch the impacting target | ≤ 100 |
| b | 8 | 7 | The probability (stored as a percent) that a target that has been launched will suffer an inflight failure | [*] ≤ 100 |
| c | 15 | 7 | The probability (stored as a percent) that a target will fail to detonate on impact | ≤ 100 |
| | | : | | |
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| | i | | | |
| s pe | r unit | 2 | . Total packed list length 1323 | bits. |

| Α. | Packed list n | ame _ | JTOUT . | BPU | name | JBITS5 | _• | Com | mon | block | name | SUMMRY | _• |
|----|---------------|--------|---------|--------|------|--------------|----|-------|------|-------|------|--------|------------|
| В. | One packed gr | oup pe | er | Target | | | of | which | ther | e may | be _ | 255 | - • |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--|---------|
| a | 1 | 6 | The number of SAM assignments made against the target | |
| b | 7 | 6 | The number of SAM launches made against the target | |
| С | 13 | 6 | The number of SAM intercepts achieved against the target | · |
| đ | 19 | 6 | The task force identification number of the SAM launcher inflicting death on this target | |
| е | 25 | 6 | The number of radar sets disabled by the impact of this target | Note 1 |
| f | 31 | 6 | The number of SAM launchers disabled by the impact of this target | Note 1 |
| g | 37 | 6 | The number of guidance channels disabled by the impact of this target | Note 1 |
| | | | | |

| D. | Bits per unit | 42 . To | otal packed list length | 10,710 | bits. |
|----|----------------|-----------------|-------------------------|--------|-------|
| Ε. | List dimension | on machine with | th word length of: | | |
| | 60 bits 1 | 79 words; 3 | 36 bits 298 words; | bits | words |
| T. | Notos | | | | |

#1. Not applicable to "killed" targets or to targets of nonimpacting types.

| A. | Packed list name | JTRGFO | BPU name JBITS3 . Common block name | TARGET |
|----|------------------|------------|-------------------------------------|--------|
| в. | One packed group | per Target | of which there may be | 255 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|----------|------------------|----------------|--|-------------------|
| a | 1 | 1 | Alive (0) or killed (1) | |
| Ъ | 2 | 1 | Active (0) or inactive (1) | |
| c | 3 | 1 | Launch plane guidance is (1) or is not (0) required during parasite flight | Note 1 |
| l a | 4 | 4 | Target type | |
| e | 8 | 4 | Number of legs in the MFP for this target | |
| f | 12 | 3x4 | Index value within PATHS array for X ₁ | |
| <u> </u> | 12 | 3,4 | of the MFP for this target | • |
| g | 24 | 4 | Jamming power density group index | "O" if nonjammer |
| l å | 28 | 2x4 | ID number of ship under attack | "O" is not a |
| 1 " | | | (actual ship attacked for TDHS) | parasite |
| i | 36 | 4 | Total number of parasites carried by this | "O" is not a |
| - | | · | launch vehicle | launch vehicle |
| j | 40 | 2x4 | ID number of mother plane or ID number | Note 2 |
| ١. | ١,, | l , | of first parasite | |
| k | 48 | 4 | Weapon profile number | |
| 1 | 52 | 4 | Launch vehicle node number from which | |
| | 56 | | parasite launch is determined | seconds |
| m | 20 | 2x4 | Displacement of launch interval from launch node above | seconds |
| l n | 64 | 4 | Launch interval width | seconds |
| " | 68 | 4 | Current node number | Initially 0 |
| P | 72 | 4 | Next parasite launch node | "O" if a parasite |
| q | 76 | li | Uniformly distributed (0) or deterministic | |
| 4 | , , , | 1 - | (1) aim point | |
| r | 77 | 10 | X-coordinate for deterministic aim point | "O" otherwise |
| 1 | | | +500 | |
| s | 87 | 10 | Y-coordinate for deterministic aim point | "O" otherwise |
| | | 1 | +500 | |
| t | 97 | 10 | Z-coordinate for deterministic aim point +500 | "O" otherwise |
| u | 107 | 2x4 | ID number of ship against which attack | "0" if not a |
| | . ` | | is intended | parasite |

| D. | Bits per unit | 106 | Total packed list length | 27,030 | bits. |
|----|---------------|-----|--------------------------|--------|-------|
| | <u> </u> | 111 | th word length of: | 29,070 | - |

| 60 bits | 451 | words; | bits | 751 | words; | bits | words | |
|---------|-----|--------|------|-----|--------|------|-------|--|
| | 485 | | | 805 | | | | |

¹For a launch vehicle, = 1 if at least one of its parasites requires guidance during flight.

² ID number < target number implies target is a parasite.

ID number > target number implies target is a launch vehicle.

ID number = 0 implies no parasites associated with this vehicle.

| Α. | Packed list name | JWPRF | BPU name | JBITS4. | Common | block | name | TARGET | • |
|----|------------------|------------|----------|---------|-----------|--------|------|--------|---|
| В. | One packed group | per Weapon | Profile | of | which the | re may | be _ | 31 | • |

| Packii | Packing Format: First Field Purpose Remarks | | | | | | | | |
|--------|--|----------------|---|----------------|--|--|--|--|--|
| Field | First Bit No. | Field Width | Purpose | Remarks | | | | | |
| а | 1 | 3 | Number of legs for this profile | 1,3, or 4 only | | | | | |
| b | 4 | 4x3 | Index value within PATHS array for first parameter of this weapon profile | | | | | | |
| | | | | | | | | | |
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| D. | Bits per unit | 15 | • | Total pac | ked lis | t length _ | | 465 | bits. | _ |
|----|----------------|---------|-------|------------------|---------|------------|--------|-----|-------|---|
| E. | List dimensio | n on ma | chine | with word | length | of: | | | | |
| | <u>60</u> bits | 8 | words | ; <u>36</u> bits | 13 | _ words; _ | _ bits | | words | |
| F. | Notes: | | | | | | | | | |

| Α. | Packed list name | KGCA | BPU nam | e <u>KBITS1</u> | Common block name _ | GUIDCH . |
|----|------------------|-----------------|--------------|-----------------|-----------------------|-------------|
| В. | One packed group | per <u>G.C.</u> | Constraint C | Group Type | of which there may be | <u>15</u> . |
| c. | Packing Format: | | | | | |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--|---------|
| a | 1 | 6 | A _{ll} value for the constraint array | · |
| b | 7 | 6 | A ₁₂ | |
| | : | ÷ | : | |
| h | 43 | 6 | A ₁₈ | |
| i | 49 | 6 | A ₂₁ | |
| : | : | : | : | |
| - | 379 | 6 | A ₈₈ | |
| | | | | |
| | | | | |
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| D. | Bits per unit _ | 384 . Total packed list length | 5760 | bits. |
|----|-----------------|--|--------|-------|
| Ε. | List dimension | on machine with word length of: | • | |
| | 60 bits | 96 words; <u>36</u> bits <u>160</u> words; | _ bits | words |
| F. | Notes: | | | |

Data is stored by rows (rather than by columns) to facilitate constraint equation multiplication within the simulation model.

| Α | Packed | list | name | KGCPC | | BPU | name | KBITS2 | | Common | block | name | GUIDCH | |
|-----|--------|------|------|-------------|---|-----|------|--------|---|--------|-------|------|--------|--|
| ••• | | | | | - | | | | - | | | | | |

B. One packed group per G.C. Constraint Group Type of which there may be 15

C. Packing Format:

| Lackii | ng Forma | | ` | |
|--------|------------------|----------------|---|---------|
| Field | First Bit No. | Field Width | Purpose | Remarks |
| а | 1 | 8 | P ₁ for inflight data rate state l | Note #1 |
| b | 9 | 8 | P ₂ for inflight data rate state 2 | |
| : | : | | • | |
| h | 57 | 8 | P ₈ for inflight data rate state 8 | Note #2 |
| i | 65 | 8 | C ₁ for inflight data rate state 1 | |
| j | 73 | 8 | C ₂ for inflight data rate state 2 | · |
| : | : | : | : | |
| р | 121 | 8 | C ₈ for inflight data rate state 8 | Note #3 |
| | | | | |

| D. | Bits p | er | unit | 128 | _• | Total | packed | list | length | 1920 | bits. |
|----|--------|----|------|-----|----|-------|--------|------|--------|------|-------|
|----|--------|----|------|-----|----|-------|--------|------|--------|------|-------|

E. List dimension on machine with word length of:

60 bits 32 words; 36 bits 54 words; bits words

#1.
$$P_{i+1} \ge P_i$$
, $i = 1, ..., 7$.

- #2. Actual number of entries corresponds to column dimension of the "A" matrix.
- #3. Actual number of entries corresponds to row dimension of the "A" matrix.

| A. | Packed list name | KGUID . | BPU name <u>KBITS3</u> | • | Commo | on block | name | GUIDCH . |
|----|------------------|---------------------|------------------------|-----------|----------|----------|------|----------|
| в. | One packed group | per <u>Guidance</u> | Channel* | of | which th | nere may | be _ | 255• |

| C. | Packing | Format: |
|----|---------|---------|

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|-----------------------------------|-----------------|
| а | 1 | 1 | Active (0) or disabled (1) | Note #1 |
| b | 2 | 7 | Associated tracking radar type | |
| С | 9 | 1 | Free (0) or committed (1) | Note #1 |
| d | 10 | 7 | Associated guidance channel group | Cross reference |
| e | 17 | 2x4 | Launcher number | Note #2 |
| f | 25 | 2x4 | Assigned target number | 11 11 |
| g | 33 | 4 | Rail number | ** ** |
| h | 37 | 4 | Missile type | 11 11 |
| i | 41 | 4 | Actual salvo size | 11 11 |
| | | | | |
| | | | | |
| | | | | |
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| | | | | |

| D. | Bits per unit | | 44 | Tota | al pac | ked lis | t length | 11 | ,220 | bits. |
|----|----------------|-----|---------|------|--------|---------|----------|------|------|-------|
| E. | List dimension | on | machine | with | word | length | of: | | | |
| | 60 bits | 187 | words | ; 36 | bits | 312 | words; | bits | wor | ds |

- #1. Fields a and b (or c and d) would normally be picked up together as a single 8 bit field. A value greater than 127 then implies a disabled (or committed) guidance channel.
- #2. These data apply to the currently held assignment; they are not applicable if the guidance channel is "free."

^{*}Supplemented by "ASGNTM" and "RELTM" arrays of assignment and release times of current assignments.

| Α. | Packed list name | KRSHPT. | BPU name KBITS4 | _ : | Common | block | name | SHIP | • |
|----|------------------|----------------------|-----------------|------------|------------|-------|------|------|---|
| В. | One packed group | per <u>Ship Type</u> | | of | which ther | e may | be _ | 31 | • |

| Packi | ng Forma | | | |
|-------|------------------|----------------|---|---------|
| Field | First Bit No. | Field Width | Purpose | Remarks |
| а | 1 | 5 | Radar type of the 1st surveillance radar for this ship type | |
| : | : | | : | |
| g | 31 | 5 | Radar type of the 7th surveillance radar for this ship type | |
| | | İ | | |
| | | | | ·. |
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| D. | Bits per unit | 35 . Total packed list length _ | 1085 | bits |
|----|----------------|---------------------------------|------|-------|
| E. | List dimension | on machine with word length of: | | |
| | 60 bits | 19 words; 36 bits 31 words; | bits | words |

| | | list nam ked grou | | Ship Type of which then | re may be 7 |
|-------------|---------|----------------------|----------------|--|-------------------------------------|
| c. | Packing | Format: | | | |
| | Field | First Bit. No | Field Width | Purpose | Remarks |
| | а | 1 | 5 | Local radar number used by the track supervisor aboard this ship type | |
| | b | 6 | 5 | Scope limit factor for the radar assigned to the track supervisor | |
| | с | 11 | 5 | Local radar number used by the first tracking operator aboard this ship type | plus 10 if in automatic offset mode |
| | d | 16 | 5 | Scope limit factor for the radar assigned to the first tracking operator | |
| | • | • | • | | |
| | m | 61 | 65 | Same as field c except for the sixth tracking operator | |
| | n | 66 | 70 | Same as field d except for the sixth tracking operator | |
| • | | | | | · |
| | | | | | |
| | | | | | |
| D. 1 | Bits pe | r unit | 7(| 7 . Total packed list length 490 | bits. |
| E. 1 | | | | hine with word length of: | |
| F. N | lotes: | D1C8 | <i>y</i> | words; 36 bits 14 words; bits | words |

| Α, | Packed list name | LAUNFO. | BPU name LBITS1 | . Com | mon block name | LAUNCH . |
|----|------------------|--------------------|-----------------|----------|----------------|----------|
| В. | One packed group | per <u>Launche</u> | r | of which | there may be | 63 |

| Field | First Bit No. | Field Width | Dunnoco | Remarks |
|-------|------------------|----------------|---|-----------------|
| а | 1 | 1 | Active (0) or disabled (1) | |
| b | 2 | 1 | Available (0) or not available (1) | set by WEPAVL |
| С | 3 | 4 | Launcher type | |
| d | 7 | 6 | Parent ship number | ≤ 31 |
| е | 13 | 2x6 | Number of the most recently serviced guidance channel | ≤ 255 |
| f | 25 | 6 | Associated guidance channel group | |
| g | 31 | 6 | Rail last scheduled for use | |
| h | 37 | 6 | Salvo size | |
| i | 43 | 6 | Missiles remaining in the magazine | · |
| j | 49 | 6 | Associated tracking radar type | cross reference |
| k | 55 | 6 | Number of intercepts achieved | |
| 1 | 61 | 6 | Number of kills achieved | |
| | | | | |
| | | | | |
| | | | | |

| D. | Bits per unit | <u>66</u> . | Total pac | ked list length | 4,158 | bits. |
|----|----------------|-------------|-------------------|-----------------|-------|-------|
| Ε. | List dimension | on machine | with word | length of: | | • |
| | 60 bits | 70 words | s; <u>36</u> bits | 116 words; | bits | words |

| Α. | Packed | list na | me <u>L</u> | CHPAR BPU name <u>LBITS2</u> . Common | block name LAUNCH | | | | |
|----|------------------------|------------------|--------------------------------|---------------------------------------|-------------------|--|--|--|--|
| в. | One pa | cked gro | oup per | Launcher Type of which ther | e may be | | | | |
| c. | Packing Format: | | | | | | | | |
| | Field | First Bit No. | Field Width | Purpose | Remarks | | | | |
| | а | 1 | 1 | Old (0) or new (1) type data | | | | | |
| | b | 2 | 1 | od (0) or bad (1) type data | | | | | |
| | С | 3 | 3 6 Missile type launched ≤ 15 | | | | | | |
| | d | 9 | 6 | Magazine capacity | | | | | |
| | e 15 6 Number of rails | | | | | | | | |
| | f | 21 | seconds | | | | | | |
| | g | 27 | 6 | Launcher reload cycle time | " | | | | |
| | h | 33 | 6 | Button pushing time delay | " | | | | |
| | | | | | | | | | |
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| | | | | | | | | | |
| | | | | | | | | | |
| D. | Rite | per unit | .3 | 8 . Total packed list length57 | 70 bits. | | | | |
| E. | | | | achine with word length of: | | | | | |
| ٠. | | bits | | | words | | | | |

| Α. | Packed list name | e <u>MNSHPT</u> BPU | name MBITS1. | Common block n | ame SHIP. |
|----|------------------|---------------------|--------------|--------------------|---------------|
| B. | One packed grou | p per Ship Type | of | which there may be | e <u>31</u> . |

| | racking rotmat. | | | | | | | |
|-------|------------------|----------------|--|---------|--|--|--|--|
| Field | First Bit No. | Field Width | Dunnaga | Remarks | | | | |
| a | 1 | 5 | Tracking radar type for the 1st guidance channel group | | | | | |
| b | 6 | 5 | G.C. constraint group type for the 1st G.C. group | ≤ 15 | | | | |
| С | 11 | 5 | Number of launcher types serviced by the 1st G.C. group | ≤ 3 | | | | |
| d | 16 | 5 | M_{11} = the 1st launcher type serviced by the 1st G.C. group | ≤ 15 | | | | |
| е | 21 | 5 | N_{11} = the number of launchers of type M_{11} serviced by the 1st G.C. group | ≤ 7 | | | | |
| f | 26 | 5 | ^M 21 | | | | | |
| g | 31 | 5 | N ₂₁ | | | | | |
| h | 36 | 5 | ^M 31 | | | | | |
| i | 41 | 5 | N ₃₁ | | | | | |
| | • | : | Repeat fields a through i for 7 G.C. groups per ship type | | | | | |
| - | 311 | 5 | N ₃₇ | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | l | | | | | | | |

| D. | Bits per unit | 315 | Total | packed | list | length | 9765 | bits |
|----|---------------|-----|-------|--------|------|--------|------|------|
| | | | | | | _ | | |

| Ε. | List | dimension | on | machine | with | word | length | of: |
|----|------|-----------|----|---------|------|------|--------|-----|
| | | | | | | | | |

| GΩ | hita | 163 | monda. | 20 | h++~ | 070 | | 1 4 | • + _ | |
|----|------|-----|--------|----|------|-----|--------|-----|-------|-------|
| 90 | DICE | 163 | worus; | ახ | DILE | 272 | words: | D: | LUS | words |
| | | | • | | | | , | | | |

F. Notes:

This packed list is used only within the Type Generator and is not included in the Replication Tape File data.

| A. | Packed list name | MSLPAR | BPU name | MBITS2 . Common block name | MISSL |
|----|------------------|--------------------|----------|----------------------------|-------|
| В. | One packed group | per <u>Missile</u> | Туре | of which there may be | 15 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--------------------------------------|---------|
| а | 1 | 1 | Old (0) or new (1) type data | , |
| Ъ | 2 | 1 | Good (0) or bad (1) type data | |
| c | 3 | 4 | Number of performance envelope nodes | NPE |
| đ | 7 | 4 | Time of flight option number | MT |
| e | 11 | 4 | Row dimension of T.O.F. array | N1 |
| f | 1 5 | 4 | Column dimension of T.O.F. array | N2 |
| g | 19 | 4 | Lethality option number | ML |
| h | 23 | 4 | Number of vulnerability groups | N3 |
| i | 27 | 10 | Cost per unit (thousands of dollars) | |
| | | | | |
| | | | | |

| D. | Bits per unit | 36 | . Total packed li | ist length 540 | bits. |
|----|----------------|------------|------------------------------|----------------|-------|
| E. | List dimension | on machine | with word length o | of: | |
| | 60 bits | 9 wor | ds; <u>36</u> bits <u>15</u> | words;bits | words |

| Α. | Packed list | name | MSLPK . | BPU name | MBITS3 | Con | nmon ! | этоск | name | MITOPT . |
|----|-------------|-------|-------------|----------|--------|-------|--------|-------|------|----------|
| в. | One packed | group | per Missile | Туре | of | which | ther | e may | be _ | 15 |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|--------------|------------------|----------------|--|---------|
| a | 1 | 7 | Parameter 1 for vulnerability group 1 | |
| b | 8 | 7 | Parameter 2 for vulnerability group 1 | |
| c | 15 | 7 | Parameter 3 for vulnerability group 1 | |
| d | 22 | 7 | Parameter 1 for vulnerability group 2 | |
| : | : | : | : | |
| _ | 302 | 7 | Parameter 2 for vulnerability group 15 | |
| - | 309 | 7 | Parameter 3 for vulnerability group 15 | |
| | | | | |
| | | | · | |
| | | | | |
| | | | · | |

| D. | Bits per unit | 315 | Total pa | cked lis | t length | 4′ | 725 | bits. |
|----|----------------|------------|------------|----------|----------|------|------|-------|
| Ε. | List dimension | on machine | with word | length | of: | | | |
| | 60 bits | 79 word | s; 36 bits | 132 | words; | bits | word | s |

F. Notes:

Each vulnerability group, i, has associated with it a lethality triple, (p_{1i},p_{2i},p_{3i}), where these parameters are interpreted according to the lethality option specified in field g of MSLPAR.

Options 1 and 2 - $p_{1i} = P_k(i) = P\{kill | target in vulnerability group i\}$ in % Option 1 - $\begin{cases} p_{2i} = \text{mean time to die, in seconds, for negative exponential distribution; } p_{3i} \text{ is unused} \end{cases}$

Option 2 - p_{2i} and p_{3i} are the mean and standard deviation, respectively, of the underlying normal distribution for log normal time to die distribution, in seconds.

| Field | First Bit. No | Field Width | Purpose | Remarks | |
|-------|------------------|----------------|---|---------|--|
| a | 1 | 8 | Component ID No. for use with Boolean functions | | |
| | | | | | |
| | | | | | |
| | | | | | |

| A. | Packed list name | NCCCDT . | BPU name | NB7 | Common block name | ne COMPON |
|----|------------------|----------|----------|-----|-------------------|-----------|
| B. | One packed group | per Comp | onent | of | which there may b | oe 620 |

| field | First Bit. No | Field Width | Purpose | Remarks | | |
|-------|------------------|----------------|---|------------------|--|--|
| a | 1 | 25 | Cumulative costs | In units of Q7Q1 | | |
| ъ | 26 | 25 | Current cost (D) | In units of Q7Q2 | | |
| ċ | 51 | 25 | Cumulative cost since last repair event (d) | In units of Q7Q3 | | |
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| D. | Bits per unit | <u>/</u> 5 | Total packe | d list length | 40,300 | DICS |
|----|----------------|---------------|--------------|---------------|--------|-------|
| E. | List dimension | on machine wi | th word leng | th of: | | |
| | 60 bits | 775 words | ; 36 bits 1 | 292 words; | bits | words |

| Packii | ng Forma | t: | | | | | | | |
|--------|---|--------------------------------|-------------------------------|----------------------|--|--|--|--|--|
| Field | First Bit No. | Field Width | Purpose | Remarks | | | | | |
| а | 1 | 1 | Old (0) or new (1) group data | - | | | | | |
| b | 2 | Good (0) or bad (1) group data | | | | | | | |
| С | c 3 3 Option number d 6 3 Number of rows in cross section data array | | | | | | | | |
| d | | | | | | | | | |
| е | 9 | 3 | Number of columns | | | | | | |
| f | 12 | 3 | Cross section model number | scintillation groups | | | | | |
| | | | | | | | | | |
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| Α. | Packed list name | NECMGP . | BPU name NBI | TS2 | Common | block nar | ne <u>CSGECM</u> . |
|----|------------------|---------------------|--------------|-----|------------|-----------|--------------------|
| В. | One packed group | per <u>ECM Load</u> | ing Group | of | which ther | e may be | 15 . |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--------------------------------|-------------------|
| а | 1 | 1 | Old (0) or new (1) group data | |
| b | 2 | 1 | Good (0) or bad (1) group data | |
| с | 3 | 1 | Communication band jammer | no (0) or yes (1) |
| d | 4 | 10 | P-band power density | w/mHz |
| e | 14 | 10 | L-band power density | 11 |
| f | 24 | 10 | S-band power density | " |
| g | 34 | 10 | C-band power density | 11 |
| h | 44 | 10 | X-band power density | " |
| | | | | |

| D. | Bits per unit | | 53 | Tota | ıl pac | cked lis | t length | | 795 | bits. |
|----|----------------|----|---------|------|--------|----------|----------|----------|-----|-------|
| E. | List dimension | on | machine | with | word | length | of: | | | |
| | 60 bits | 14 | words | ; 36 | bits | 23 | words; | bits | | words |

| Α. | Packed list name | NGCTYP . | BPU name | NBITS3 . | Common | block | name | GUIDCH | |
|----|------------------|---------------------|----------|-------------|-------------|-------|------|--------|---|
| в. | One packed group | per <u>G.C.C.G.</u> | Туре | of | which there | e may | be _ | 15 | |
| c. | Packing Format: | | | | | | | | |
| | First Fie | eld | | | | | | | ٦ |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|---|----------------|-----------------------------------|---------|
| а | 1 | 1 | Old (0) or new (1) type data | |
| b | 2 | 1 | Good (0) or bad (1) type data | |
| С | 3 | 2x3 | Total number of guidance channels | ≤ 31 |
| d | 9 | 3 | Number of inflight transitions | < 7 |
| e | e 12 3 Number of constraint equations minus 1 | | | ≤ 7 |
| | | | | |
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| D. | Bits per unit | <u>14</u> . Tota | ıl packed list | length | 210 | bits. |
|----|----------------|------------------|----------------|--------|------|-------|
| Ε. | List dimension | on machine with | word length o | f: | | |
| | 60 bits | 4 words; 36 | bits | words; | bits | words |

| A. | Packed list name | NONOFF | BPU name | NTBITS | Common block name | TONOFF . |
|----|------------------|-------------|----------|--------|--------------------|----------|
| D | One nacked group | ner Compone | ant | of | which there may be | 620 |

| Field | First Bit. No | Field Width | Purpose | Remarks | | |
|-------|------------------|----------------|-------------------------|------------------|--|--|
| a | 1 | 30 | Time OFF | In units of Q9Q2 | | |
| ъ | 31 | 7 | Number of DAMAGE EVENTS | | | |
| ċ | 38 | 7 | Number of FAIL EVENTS | | | |
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| D. | Bits per unit | 44 | . Total pa | cked list length | 27,280 | bits |
|----|---------------|----|------------|------------------|--------|------|

E. List dimension on machine with word length of:

| 60 | bits | 455 | words; | 36 | bits | 758 | words; | bits | words |
|----|------|-----|--------|----|------|-----|--------|------|-------|
| | | | - | _ | | | | | |

| Α. | Packe | d list n | ame <u>1</u> | NPSHPT . BPU name NBITS4 . Common | block name SHIP |
|----|-------|------------------|----------------|-----------------------------------|-----------------|
| в. | One p | acked gr | oup per | Ship Type of which ther | re may be 31 |
| c. | Packi | ng Forma | t: | , | |
| | Field | First Bit No. | Field Width | Purpose | Remarks |
| | а | 1 | 1 | Old (0) or new (1) type data | |
| | b | 2 | 1 | Good (0) or bad (1) type data | |
| | С | 3 | 4 | Number of scanning radar sets | ≤ 7 |
| | d | 7 | 4 | Number of guidance channel groups | ≤ 7 |
| | е | 11 | 2x4 | Total number of guidance channels | ≤ 63 |
| | f | 19 | 4 | Total number of missile launchers | ≤ 15 |
| | g | 23 | 2x4 | Minimum assign to launch time | seconds |
| | h | 31 | 2x4 | Maximum assign to launch time | seconds |
| | | | | | |
| | | | | . Total packed list length 117 | 78 bits. |
| E. | | | | chine with word length of: | |
| F. | 60 1 | oits | 20 | words; 36 bits 33 words; bits | words |

| A. | Packed list name | NSPGO | BPU name | NB5 . Com | mon block name | COMPON . |
|----|------------------|-----------|----------|-----------|----------------|----------|
| В. | One packed group | per Entry | (Note 1) | of whic | h there may be | 1178 |

| field | First Bit. No. | Field Width | Purpose | | Remarks |
|-------|-------------------|----------------|--------------------------------|---|--------------|
| | K# | 10 | Depth of keel | | feet, Note 2 |
| | K+1 | 10 | Hull Descriptor | | feet, Note 3 |
| | K+2 | 10 | Hull Descriptor | | feet |
| | K+3 | 10 | Hull Descriptor | | feet |
| | K+4 | 10 | Hull Descriptor | | feet |
| | K+5 | 10 | Hull Descriptor | | feet |
| | K+6 | 10 | Hull Descriptor | | feet |
| | K+7 | 10 | Height of main deck from water | | feet |
| : | K+8 | 10 | Position of X + 500 | | feet |
| | K+9 | 10 | Rectangular Y + 500 | | feet |
| | K+10 | 10 | Solid Y + 500 | | feet |
| | K+11 | 10 | Dimensions length | | feet Note 4 |
| | K+12 | 10 | of rectang- width | | feet |
| | к+13 | 10 | ular solid height | | feet |
| | . : | | | | |
| | : NNSPGO | (N+1) | | | |
| | | | | | |
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| D. | Bits per unit | 10 | Total packed list | length | 11,780 | bits. |
|----|----------------|---------------|--------------------|--------|--------|-------|
| E. | List dimension | on machine wi | th word length of: | : | | |
| | 60 bits | 197 words | s; 36 bits 328 | words; | bits | words |
| ₽ | Notes | | | | | |

¹ The entries for ship type number N are stored in unit numbers NNSPGO(N) through
 [NNSPGO (N+1) - 1]
2 K = NNSPGO(N)

 $^{^{\}mathbf{3}}\mathbf{See}$ amplification of card type TSH in Appendix A

⁴Measured from stern to bow

| A. | Packed list name | NSTCOM . | BPU name | NB1 | Common blo | ck name | COMPON |
|----|------------------|----------|----------------|-----|-------------|---------|--------|
| В. | One packed group | per Ship | Type Component | of | which there | may be_ | 620 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|-------------------------------------|---------|
| a | 1 | 7 | Component ID No. | |
| Ъ | - 8 | 7 | Component Type No. | |
| С | 15 | 7 | Scenario Cost Index | |
| ď | 22 | 8 | field presently unused | |
| e | 30 | 11 | X-position coordinate + 500 | feet |
| £ | 41 | 11 | Y-position coordinate + 500 | feet |
| g | 52 | 11 | Z-position coordinate + 500 | feet |
| h | 63 | 1 | Exterios (1)/Interior (0) Indicator | |
| i | 64 | 5 | System Code, if applicable | Note 1 |
| j | 69 | 5 | System Type No., if applicable | |
| | | | | |

| F. | Notes: | | | | | |
|----|----------------|--------------|------------------|---------------|--------|-------|
| | 60 bits_ | 755 word | ls; 36 bits 1258 | words; _ | bits | words |
| E. | List dimension | on machine v | with word length | of: | | |
| D. | Bits per unit | | Total packed | list length _ | 45,260 | bits. |
| | | | | | | |

System Code:

Radar = 1
Guidance Channel = 2
Launcher = 3
All others = 0

| A. | Packed list name | NTGPAR | BPU name | NBITS5 Common block name | TARGET |
|----|------------------|------------|----------|--------------------------|--------|
| В. | One packed group | per Target | Туре | of which there may be | 15 |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|-------------------------------|--------------------------|
| a | 1 | 1 | 01d (0) or new (1) type data | |
| Ъ | 2 | 1 | Good (0) or bad (1) type data | i.e., well-defined |
| С | 3 | 1 | Guidance dependency | Note 1 |
| đ | 4 | 4 | Vulnerability group index | ≤ 15 |
| е | 8 | 4 | Cross section group index | ≤ 15 |
| f | 12 | 10 | DEP/CEP | feet |
| g | 22 | 10 | REP/option | Note 2 |
| h | 32 | 10 | Velocity standard deviation | feet per second |
| i | 42 | 1 5 | Warhead lethality | equivalent pounds TNT |
| j | 57 | 10 | Fuze delay distance | feet |
| k | 67 | 7 | 100 x probability of dud | |
| 1 | 74 | 15 | missile sensor wavelength | centimeters |
| | | | | |
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| D. | Bits | per | unit | 88 | Total | packed | list | length | 1320 | bits. |
|----------|------|-----|-------|--------------|----------|----------|-------|--------|------|-------|
| ~ | Tick | 41- | naian | on machine m | deb more | 1 1anati | . Af. | | | |

E. List dimension on machine with word length of:

| | bits | 22 | words; | 36 | bits | 37 | words; | bits | words |
|---|------|----|--------|----|------|----|--------|------|-------|
| _ | | | | _ | | | | | |

F. Notes:

 $[\]frac{1}{0}$ - no dependency; 1 - dependency exists (for at least one parasite in the case of a launch vehicle)

 $^{^2}$ If equal to 0, then field f is interpreted as a CEP value. Otherwise, field f is DEP and field g is REP, both in feet

| | | · | ı | | |
|-------------|---------|------------------|----------------|--|------------------|
| A. : | Packed | list nam | ne <u>N</u> | TRHO . BPU name NB9 . Common bl | lock name COMPON |
| В. (| One pac | ked grou | ıp per | Component of which then | re may be 620 |
| C. 1 | Packing | Format: | | | |
| | Field | First Bit. No | Field Width | Purpose | Remarks |
| | а | 1 | 30 | Time of last event (au) | In units of Q9Q1 |
| | Ъ | 31 | 30 | Time of last off (zero if on) | In units of Q9Q2 |
| | с | 61 | 20 | Repair rate that is currently being applied (rc) | In units of Q9Q3 |
| | đ | 81 | 20 | Repair rate as determined by last damaged or fail event (ρ) | In units of Q9Q4 |
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|----|----------------|-----------|-----------------|-----------------|--------|-------|
| D. | Bits per unit | 100 | Total pac | ked list length | 50,000 | bits. |
| E. | List dimension | on machin | ne with word le | ngth of: | - | |
| | 60 bits | 1034 | words; 36 bits | 1723 words; | bits | words |
| | | | | | | |

| A. | Packed list name | NUDOOF . | BPU name | NB6 | Common block i | name | COMPON | |
|----|--------------------|-----------|----------|-----|-----------------|------|--------|------------|
| в. | One packed group p | per Compo | nent | of | which there may | 7 be | 620 | _ : |
| C | Dealine Format. | | | * | | | | |

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|-----------------------|---------|
| a | 1 | 1 | Up (0)/Down (1) State | |
| ъ | 2 | 1 | On (0)/Off (1) State | |
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| D. | Bits | per unit | | ·• | Total | packed | list | length | 1240 | bits. |
|----|------|-----------|---------|---------|-------------|----------|-------|--------|------|-------|
| E. | List | dimension | on mach | ine wit | h wor | d lengtl | n of: | | | |
| | | 60 bits | 21 | words | 36 b | its3 | 35 | words; | bits | words |

| Α. | Packed list name | NVSHPT | BPU name | NBITS6 . | Common | block | name | SHIP | _• |
|----|------------------|--------------|----------|----------|-----------|-------|------|------|----|
| В. | One packed group | per Ship Typ | ·e | of | which the | e may | be _ | 31 | .• |
| c. | Packing Format: | | | | | | | | |

| Field | First Bit No. | Field Width | Purpose | Remarks |
|-------|------------------|----------------|--|--|
| а | 1 | 6 | $ ho_1$ - radial distance to 1st component group | 10's of feet |
| b | 7 | 6 | θ_1 - bearing to the 1st component group | 6° steps CW from bow |
| С | 13 | 6 | $\mathbf{z_1}$ - height of 1st component group above ship Z coordinate | feet |
| d | 19 | 6 | v ₁ - vulnerability factor for 1st component group | |
| е | 25 | 6 | n_1 - number of components in the 1st component group | |
| : | : | : | : : | |
| - | 271 | 6 | P ₁₀ | |
| - | 277 | 6 | θ ₁₀ | |
| - | 283 | 6 | ^z 10 | |
| - | 289 | 6 | v ₁₀ | |
| - | 295 | 6 | n ₁₀ | THE CONTRACTOR OF THE CONTRACT |
| | | | | |
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| D. | Bits per unit 300 . Total packed list length 9300 bits. |
|----|---|
| E. | List dimension on machine with word length of: |
| | 60 bits 155 words; 36 bits 259 words; bits words |
| | |

Appendix C

DEFINITIONS OF VARIABLES IN COMMON

Appendix C

DEFINITIONS OF VARIABLES IN COMMON

There are 48 labeled common blocks used in the simulation, including 11 unique to the TDHS version.* On the following pages, the contents of each common block is specified by giving the name, dimensions, and a brief description of each parameter within the block Dimensions are specified for two configurations of the simulation model:

Full. All arrays and packed lists are at their maximum allowable dimensions. Full task force runs with large raid sizes may be conducted with this configuration.

Reduced. Many arrays and packed lists are reduced in size from their maximum potential. Single ship and small task force runs with limited raid sizes may be conducted with this configuration.

The purpose of the reduced configuration is to allow smaller and simpler runs to be made at lower cost since less central memory space is required. Of lesser importance is that the replication data tape file will be shorter, thus reducing reading and writing times. Table C-1 shows the sizes of various kinds of units associated with the two model configurations. These sizes have been given names and are further discussed in common block MAXES. An index to the various common blocks is presented in Table C-2.

As a general rule, the Type Data lists and arrays have not been reduced, on the basis that the range of options and configurations afforded by these data should be available in full even for individual runs of quite limited scope. The reduced configuration given here is just one of numerous possible ways to accomplish this objective. Any user of the model who determines that some other combination of size reductions is advantageous can redimension the common block lists and arrays as appropriate, following the procedure outlined in Appendix D.

^{*} Blank (unlabeled) common storage is not used in the model.

Table C1 - Full and Reduced Unit Sizes

| Number of: | Si | zes | Size |
|--|-------------|------|--------|
| | Ful1 | Ređ. | Name |
| Component types | 200 | 100 | NCTMAX |
| Ship types | 31 | 7 | NSTMAX |
| Ship-type components | 620 | 140 | ICOMAX |
| Rectangular solids | 1 55 | 35 | |
| Ships | 31 | 7 | ISMAX |
| Components | 620 | 140 | |
| Boolean functions | 620 | 140 | MBF |
| Boolean function variables | 3100 | 700 | MBV |
| Radar types | 31 | 31 | NRTMAX |
| Radar sets | 63 | 15 | IRMAX |
| Guidance-channel-group types | 15 | 15 | NGCTMX |
| Guidance-channel groups | 63 | 15 | IGCGMX |
| Guidance channels | 255 | 63 | IGCMAX |
| Launcher types | 15 | 15 | NLTMAX |
| Launchers | 63 | 15 | ILMAX |
| Missile types | 15 | 15 | NMTMAX |
| Target types | 15 | 15 | NTTMAX |
| Target cross-section groups | 15 | 15 | NCSGMX |
| Target ECM loading groups | 15 | 15 | NECMAX |
| Targets | 255 | 63 | JTMAX |
| Weapon (parasite) profile descriptions | 31 | 31 | JWPMAX |

Table C2 - Common Blocks

| Common Block | Si | ze | Remarks | Page Number |
|-----------------|------|------------|---------------|----------------|
| Name | Full | Red. | | |
| BOOL | 3519 | 719 | | C- 4 |
| CALNDR | 1093 | 493 | Note 1 | C- 5 |
| CARDFO | 185 | 185 | Notes 2 and 4 | C- 6 |
| COMPON | 3838 | 1054 | Note 3 | C- 7 |
| CONSOL | 5050 | 36 | | C-11 |
| COSTS | 6 | 6 | | C-10 |
| CONSTS | 4 | 4 | | C-12 |
| CSGECM | 755 | 125 | Note 3 | C-13 |
| DRATO | 51 | 51 | 11000 3 | C-14 |
| DROPQ |] | 55 | • | C-15 |
| ENVRON | 3 | 3 | | C-16 |
| ERRORS | 2 | 2 | Note 2 | C-17 |
| EVENTS | 45 | 45 | Note 2 | C-18 |
| GUIDCH | 356 | 192 | Note 3 | C-21 |
| 10 | 7 | 7 | | C-22 |
| LAUNCH | 82 | 29 | Note 3 | C-23 |
| LCHSEC | 378 | 90 | | C-24 |
| MAXES | 20 | 20 | | C-25 |
| MISSL | 1093 | 1093 | Note 3 | C-28 |
| MPARAM | 6 | 6 | Note 3 | C-29 |
| NAMES | 466 | 418 | Note 4 | C-30 |
| NEXTUP | 5 | 5 | 1020 | C-31 |
| OPTION | 52 | 52 | | C-32 |
| RADAR | 378 | 354 | Note 3 | C-33 |
| RADSEC | 441 | 105 | | C-34 |
| RAID | 4 | 4 | Note 2 | C-35 |
| RANDOM | 74 | 74 | | C-36 |
| RDRSMR | 1 | 24 | | C-37 |
| REP | 7 | 7 | Note 4 | C-38 |
| RSET | | 10 | | C-39 |
| SHIP | 535 | 401 | Note 3 | C-40 |
| SHPTYP | 194 | 194 | | C-41 |
| SRVTIM | i | 18 | | C-42 |
| SUMMRY | 936 | 226 | Note 3 | C-43 |
| SUNS | 153 | 378 | | C-44 |
| TARGET | 2113 | 497 | Notes 3 and 5 | C-45 |
| İ | 2137 | 421 | Note 6 | C-45 |
| TELCOMM | 322 | 84 | Note 3 | C-46 |
| TIMCHK | 60 | 60 | | C-47 |
| TIMES | 515 | 131 | | C-48 |
| TRACK | | 1637 | | C-49 |
| TRGDTA | 4362 | 978 | Note 3 | C-51 |
| TRKCOL | | 63 | | C-52 |
| TRKSMR | 1 | 124 | | C-53 |
| VID | Ì | 257 | , | C-56 |
| VIDTRK | 600 | 4097 | | C-57 |
| WASTE WEAPON | 355 | 600 355 | | C-58 |
| ZBOOL | 333 | 300 | | C-59 C-61 |
| 2000L | | | | 0-01 |

NOTES:

¹The length of this common block includes an arbitrary allowance for the game event calendar.

 $^{^{2}}_{\hbox{\scriptsize This common block is used only in the Pregame Processor.}}$

Packed list length(s) included in the size of this common block are based on a machine capable of storing 20 characters in two machine words

⁴ Alphanumeric array lengths included in the size of this common block are based on a machine capable of storing 20 characters in two machine words.

⁵The length of this common block includes an arbitrary allowance for the target master flight path data array.

This dimension of the common block includes storage unique to the TDHS version of the model.

Common block name

BOOL

Sizes: Full 3159 , Reduced 719

| Parameter | Dimens | sions | |
|-----------|--------|-------|---|
| Name | Ful1 | Red. | Description |
| IBOLFN | 259 | 59 | Packed list containing function number, begin- ning location, and number of Boolean variables in IBOLV, and logic indicator for each Boolean function. |
| IBN | 1 | 1 | The number of bits required to store the information in IBOLFN for one Boolean function. |
| IBOLV | 414 | 94 | Packed list containing Boolean variables for each Boolean function. |
| IBV | 1 | 1 | The number of bits required to store the information in IBOLV for one Boolean function. |
| IBORD | 1240 | 280 | List of ordered pairs of numbers, relating each Boolean function number with its index in IBOLFN. |
| IBIND | 1240 | 280 | List of ordered pairs of numbers, relating the initial Boolean function number of a run of consecutive numbers with its index in IBORD. |
| NBF | 1 | 1 | Number of Boolean functions. |
| IAND | 1 | 1 | The word AND. |
| IØR | 1 | 1 | The word OR. |
| IBLANK | 1 | 1 . | A blank character. |
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Common block name CALNDR . Sizes: Full 1093 , Reduced 493 +

| Parameter | Dimensions | | | | |
|-----------|------------------|---------|---|--|--|
| Name | Full | Red. | Description | | |
| LENCAL | 1 | 1 | Current length of the game event calendar. (Same value as KLNGTH in common block NEXTUP.) | | |
| LSIE | 1 | 1 | A multiplication factor used to pack the first integer parameter of an event into its NCAL word (see below). Equals 2^{10} . | | |
| LSNE | 1 | 1 | A multiplication factor used to pack the type number of an event into its NCAL word (see below). Equals 2^{20} . | | |
| ENAMES | † 45 | † 45 | An array of game event names to which values are assigned with a DATA statement in subroutine GAMINI; used with an A6 format for event listing printouts. | | |
| NPRIOR | + 45 | + 45 | Priority ranking table used for scheduling simultaneous events. | | |
| NCAL | 500 [‡] | 200 | An array each word of which contains the event type number and two integer parameters for a single calendar entry packed as follows: LSNE*NE+LSIE*IE+JE. | | |
| TCAL | 500 | 200 | An array of event times corresponding to the NCAL array above. TCAL, NCAL, and LENCAL together constitute the game calendar. | | |
| NEVSEQ | 1 | 1 | The cumulative number of events processed during play of the game. | | |
| | | | | | |

Notes:

The dimension of this array must be at least as large as the highest numbered event type to be processed.

The length of the calendar arrays is set arbitrarily; greater or lesser dimensions may be found advisable after some experience in using the model has been developed.

| Common b | olock n | ame | CARDFO | Sizes: | Full | 185 | , Reduced | 185 | |
|----------|---------|-----|--------|--------|------|-----|-----------|-----|--|
| | | | | | | | | | |

| Parameter | Dimensions | | |
|-----------|----------------|----------------|---|
| Name | Full | Red. | Description |
| ACARD | 2 [†] | 2 [†] | Array into which 20 character BCD fields are read from cards. |
| ALPHAS | 26 | 26 | Array containing the letters A through Z. |
| A1CARD | 3 | 3 | Array into which columns 1 through 3 are read from cards. |
| FLTARY | 64 | 64 | Floating point variables read from one or more cards by subroutine CRDARY are transferred into this array. |
| FPCARD | 7 | 7 | Array containing the floating point variables read from one data card. |
| INTARY | 64 | 64 | Integer variables read from one or more cards by subroutine CRDARY are transferred into this array. |
| IONE | 2 | 2 | Storage area for the integers 1 and 0. |
| I2CARD | 1 | 1 | Contains the integer value read from columns 4 and 5 of a data card. |
| I5CARD | 14 | 14 | Contains integer variables read from one data card. |
| MLIST | 1 | 1 | Option indicator for printing the type data where: the value 1 means print all types for which there is data and, the value 0 means print only the newly defined types (i.e., those types read from the card reader file). |
| M8080 | 1 | 1 | Print option indicator where: the value 1 means produce a single-spaced listing of all card inputs printing each card with the same format used for reading the card (which means it is not truly an 80-80 listing since the formats are not strictly FORTRAN A-type conversions) and, the value 0 means this listing is not desired. |
| | | | |

Notes:

[†] The dimension of this alphanumeric array corresponds to the number of machine words being used to store 20 BCD characters.

Common block name COMPON . Sizes: Full 3838* , Reduced 1054*

| Parameter | Dimensions | | |
|-------------|------------|------|---|
| Name | Full | Red. | Description |
| 1B 1 | 1 | 1 | Number of bits required to store the information in ICOMPO for one component. |
| IBITS8 | 1 | 1 | Number of bits required to store the information in ICTPAR for one component type. |
| ICOMPO | 124 | 28 | Packed list of integer parameters for components. |
| ICTPAR | 610 | 305 | Packed list of integer parameters for up to NCTMAX component types. |
| NB1 | 1 | 1 | Number of bits required to store the information in NSTCOM for one ship type component. |
| NB2 | 1 | 1 | Number of bits required to store the information in NBOVAR for one ship type component. |
| NB5 | 1 | 1 | Number of bits required to store the information in NSPGO for one entry (Note 1). |
| NB6 | 1 | 1 | Number of bits required to store the information in NUDOOF for one component. |
| NB7 | 1 | 1 | Number of bits required to store the information in NCCCDT for one component. |
| NB9 | 1 | 1 | Number of bits required to store the information in NTRHO for one component. |
| NBOVAR | 83 | 19 | Packed list of component identification numbers for up to ICOMAX ship-type components. |
| NCCCDT | 775 | 175 | Packed list of costs for each component. |
| NCOMP | 32 | 8 | Ship-type components assigned to ship type I are indexed from NCOMP(I) through [NCOMP(I+1)-1] The indices I and NCOMP(J) are assigned by the PGP. |
| (| | | |

Notes

^{*}These figures are based upon a machine word length of 60 bits.

 $^{^{1}}$ See packed list description for NSPGO in Appendix B for explanation of entry.

| Parameter | Dimen | sions | |
|----------------------|-------------|-------------|--|
| Name | Full | Red. | Description |
| NCOMPS | 32 | 8 | Components assigned to Ship J are indexed from NCOMPS(J) through [NCOMPS(J+1)-1]. The Indices J and NCOMPS(K) are assigned by the PGP. |
| NNSPGO | 32 | 8 | Ship-geometry descriptors for Ship Type I are in units NNSPGO(I) through [NNSPGO(I+1)-1] in the packed array NSPGO. |
| NSHPS | 1 | 1 | Number of ships in a run of the game. |
| NSHPT | 1 | 1 | Number of ship types in a run of the game. |
| NSNST | 31 | 7 | Ship number I has Ship-Type Number NSNST(I). Both I and NSNST(I) are assigned by the PGP. |
| NSOFET | 31 | 7 | NSOFET(J) is the total number of ships of Type J, where J is assigned by the PGP. |
| NSPGO | 197 | 45 | Packed array of ship geometry descriptors for up to NSTMAX ship types. |
| NSTCOM | 7 55 | 171 | Packed array of integer parameters for up to ICOMAX ship-type components. |
| NSTPN | 31 | 7 | NSTPN(I) is the user assigned ship-type number, where I is the ship-type number assigned by the PGP. |
| NTRHO | 1034 | 235 | Packed list of integer parameters for components |
| NUDOOF | 21 | 5 | Packed list of On/Off-Up/Down states for components. |
| NUN | 31 | 7 | NUN(I) is the user assign number of Ship I, where I is assigned by the PGP. |
| Q4Q1 Q4Q2 | 1 1 | 1 1 | Scaling factors for storing information in packed list ICTPAR. |
| Q7Q1 Q7Q2 Q7Q3 | 1 1 1 | 1 1 1 | Scaling factors for storing information in packed list NCCCDT. |

Common block name COMPON (Concluded)

| Parameter | Dimens | sions | |
|------------------------------|------------------|---------------------------------------|--|
| Name | Full | Red. | Description |
| Q9Q1 Q9Q2 Q9Q3 Q9Q4 | 1 1 1 1 | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | Scaling factors for storing information in packed lists NONOF and NTRHO. |
| | | | |

Common block name

COSTS

Sizes: Full 6, Reduced 6

| Parameter | Dimen | sions | | | |
|-----------|-------|-------|---|--|--|
| Name | Full | Red. | Description | | |
| NDMCT | 2 | 2 | Integer array containing total cost of failure and damage incurred by the task group. The first entry is the running cost of damage for the current replication, and the second entry is the accumulated cost for all completed replications for the current run. | | |
| NORDCT | 2 | 2 | Integer array containing the total cost of ordnance expended by the task group. Entries are analogous to those in NDMCT. | | |
| NSCNCT | 2 | 2 | Integer array containing total scenario cost as a consequence of damage and failure. Entries are analogous to those in NDMCT. | | |
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Common block name CONSOL . Sizes: Full _____, Reduced 36 .

| Parameter Name | Dimensions | | |
|-------------------|------------|------|--|
| | Full | Red. | Description |
| ICOPER | | 5 | Packed list of integer parameters for up to ICMAX tracking operators. |
| IBITS8 | | 1 | The number of bits required to store the information in ICOPER for one tracking operator. |
| THETAZ | | 3 | The boundaries in radians of the primary and secondary zones of interest, where (1) represents the smaller boundary of the primary zone, (2) the larger (smaller) boundary of the primary (secondary) zone, and (3) the larger boundary of the secondary zone. |
| ITRSUP | | 7 | Packed list of integer parameters for the track supervisor. |
| IBITS9 | | 1 | The number of bits required to store the information in ITRSUP for one track supervisor. |
| JTADD | | 1 | Whenever a track is established, this variable is used as the threshold for determining whether or not to activate an additional tracking operator. |
| JTSUB | | . 1 | Whenever a track is dropped this variable is used as the threshold for determining whether or not to deactivate a tracking operator. |
| ZWIDTH | | 1 | The fraction of the radar scope (e.g., 80/360) covered by the primary and secondary zones of interest. |
| TSEQ | | 7 | An array of times for each of ICMAX operators indicating the time at which an operator completed his most recent service operation. |
| NSEQ | | 7 | The number of times each tracking operator has been sequenced to a track. |
| NAOPS | | 1 | The number of currently active tracking operators. |
| | | | |
| | | | |

Common block name CONSTS . Sizes: Full 4 , Reduced 4

| Parameter Name | Dimensions | | |
|-------------------|------------|------|-----------------------------------|
| | Full | Red. | Description |
| PI | 1 | 1 | The numerical value 3.1415926536. |
| PIOVR2 | 1 | 1 | The value of PI divided by 2. |
| RADIAN | 1 | 1 | 180 divided by the value of PI. |
| TWOPI | 1 | 1 | Two times the value of PI. |
| | | | |

Common block name CSGECM . Sizes: Full 755, Reduced 125,

| Parameter | Dimensions | | |
|-----------|------------|--------|---|
| Name | Full | Red. | Description |
| CSDATA | 7,7,15 | 7,1,15 | Radar cross section data for up to 15 cross section groups. The reduced dimension permits only cross-section option 1 (see Card Type TC). |
| NCSGRP | 4* | 4* | Packed list of integer parameters for up to NCSGMX cross-section groups. |
| NBITS1 | 1 | 1 | The number of bits required to store the information in NCSGRP for one cross-section group. |
| NECMGP | * 14 | 14* | Packed list of integer parameters for up to NECMAX ECM loading groups. |
| NBITS2 | 1 | 1 | The number of bits required to store the information in NECMGP for one ECM loading group. |
| | | | |

Notes:

 $^{^{*}}$ These figures are based upon a machine word length of 60 bits.

Common block name DRATO . Sizes: Full 51 , Reduced 51

| Parameter Name | Dimensions | | |
|-------------------|------------|------|---|
| | Full | Red. | Description |
| RATIO | 50 | 50 | Floating-point array of damage parameters. The array is used to pass parameters from event IMPACT to the resulting DAMAGE events. |
| NDAR | . 1 | 1 | Integer pointer for the above array. |
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Reduced

Dimensions Parameter Description Name Ful1 Red. LTSQ1 Points to the location in the array KTSQ (below) of the next track to be removed from the queue. NTSQ1 The number of tracks currently stored in the array KTSQ. *KQLONG* 1 The dimension of the array KTSQ. KTSQ 20 An array, called the drop-track queue, which contains tracks to be dropped by the track supervisor. **TIMEIN** 20 The time that a track was entered into the array KTSQ. LENTHQ 4 An array containing the minimum and maximum droptrack queue lengths along with two parameters used to compute the average queue length during the game. **QLTIME** 2 The time at which the minimum and maximum queue length, respectively, was attained. WAITIM 6 A 2 x 3 array where column 1 contains the minimum waiting time along with the time of occurrence, column 2 the maximum and its occurrence time, and row 1, column 3 the total waiting time.

Common block name

ENVRON

Sizes: Full 3, Reduced 3

| Parameter | Dimensions | | | | | | | | | |
|-----------|------------|------|--|--|--|--|--|--|--|--|
| Name | Full | Red. | Description | | | | | | | |
| WINDSP | 1 | 1 . | Wind speed (scenario) | | | | | | | |
| ALTUDE | 1 | 1 | Altitude at which the wind speed was taken | | | | | | | |
| REFCOF | 1 | 1 | Nominal reflection coefficient | | | | | | | |
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| Common | block | name | ERRORS | Sizes: | Full | 2, | Reduced | 2 |
|--------|-------|------|--------|--------|------|----|---------|---|
| | 4 | | | | | | | |

| Parameter | arameter Dimensions | | | | | | | |
|-----------|---------------------|------|--|--|--|--|--|--|
| Name | Ful1 | Red. | Description | | | | | |
| NPFLAG | 1 | 1 | A flag used to indicate whether or not one or more nonfatal errors have been detected for the current type data being processed. | | | | | |
| NUMNF | 1 | 1 | The total number of nonfatal errors detected by the pregame processor. | | | | | |
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| Common block | name | EVENTS | • | Si | zes: | Ful1 | , | Reduced _ | 45* |
|----------------------|------|--------|--------|----|------|--------|--------------|--|-----|
| Parameter Dimensions | | | | | | | | | |
| Name | Ful1 | Red. | | | | | Description | | |
| IXSCAN | 1 | 1 | Number | of | the | Event | SCAN. | | |
| IXDETC | 1 | 1 | 11 | 11 | ** | 71 | DETECT. | | |
| IXPASS | 1 | 1 | ** | 11 | ** | ** | PASS. | | |
| IXPSDT | 1 | 1 | 11 | 11 | ** | ** | PASDET. | | |
| IXLOSE | 1 | 1 | " | 11 | 11 | ** | LOSE. | | |
| IXNODE | 1 | 1 | " | ** | ** | 11 | NODE. | ······································ | |
| IXVNSH | 1 | 1 | '' | " | " | 11 | VANISH. | | |
| IXIMPT | 1 | 1 | " | 11 | " | 11 | IMPACT. | | |
| IXASGN | 1 | 1 | " | " | *** | 11 | ASSIGN. | | |
| IXLNCH | 1 | 1 | ,, | " | 11 | 11 | LAUNCH. | | |
| IXINTC | 1 | 1 | 11 | " | 11 | 11 | INTCPT. | | |
| IXRELS | 1 | 1 | ,, | ** | ** | 11 | RELEAS. | | |
| IXTRNS | 1 | 1 | '' | 11 | " | " | TRNSFR. | | |
| IXABRT | 1 | 1 | " | ** | 11 | " | ABORT. | | |
| IXDIE | 1 | 1 | " | ** | " | *** | DIE. | | |
| IXTEWA | 1 | 1 | " | ** | | 11 | TEWA. | | |
| IXDROP | 1 | 1 | " | " | " | 11 | DROP. | | |
| IXEMRG | 1 | . 1 | ,, | 11 | ** | 11 | EMERGE. | | |
| | | | l | | Co | ntinue | ed on next p | age | |

^{*}The last 14 event types are unique to the TDHS version.

| Parameter | meter Dimensions | | Decarintion | | | | | |
|-----------|------------------|------|-------------|---------|------|-------|-------------|--|
| Name | Full | Red. | | | | L | Description | |
| IXVCTM | 1 | 1 | Number | of | the | Event | VICTIM. | |
| IXENTR | 1 | 1 | 11 | 11 | 11 | 11 | ENTER. | |
| IXLEAV | 1 | 1 | 11 | ; †† | ** | 11 | LEAVE. | |
| IXDISR | 1 | .1 | 11 | 11 | 11 | 11 | DISRDR. | |
| IXDISC | 1 | 1 | 11 | " | 11 | 11 | DISCHN. | |
| IXDISL | 1 | 1 | 11 | " | " | 11 | DISLAN. | |
| 1XCOME | 1 | 1 | 11 | 1! | 11 | 11 | COMEIN. | |
| IXGO | 1 | 1 | 11 | 11 | 11 | 11 | OUTGO. | |
| IXFAIL | 1 | 1 , | 21 | 11 | 11 - | 11 | FAIL. | |
| IXDOWN | 1 | 1 | 11 | 11 | 11 | 11 | DOWN. | |
| IXRPAR | 1 | 1 | 11 | 11 | 11 | 11 | REPAIR. | |
| IXDMGE | 1 | 1 | 11 | 11 | 11 | 11 | DAMAGE. | |
| IXUP | 1 | 1 | 11 | †† | 11 | 11 | UP. | |
| IXTRSP | 1 | 1 | 11 | tt | 11 | 11 | TRKSUP. | |
| IXTRKR | 1 | 1 | 11 | 11 | 11 | 11 | TRACKER. | |
| ISDRTK | 1 | 1 . | 11 | 11 | 11 | 11 | DROPTK. | |
| IXSPLT | 1 | 1 | tr . | 11 | 11 | 11 | SPLITK. | |
| IXUPD | 1 | 1 | 11 | 11 | 11 | *** | UPDATE. | |

| Parameter | Dimensions | | | | | | | |
|-----------|------------|------|-----------------------------|--|--|--|--|--|
| Name | Full | Red. | Description | | | | | |
| IXMISS | 1 | . 1 | Number of the Event MISSTK. | | | | | |
| IXNEWD | 1 | 1 | Number of the Event NEWDET. | | | | | |
| IXWAKE | 1 | 1 | Number of the Event WAKEUP. | | | | | |
| IXSLEP | 1 | 1 | Number of the Event SLEEP. | | | | | |
| IXPLF | 1 | 1 | Number of the Event PRELF. | | | | | |
| IXIFF | 1 | 1 | Number of the Event IFFAIL. | | | | | |
| IXDF | 1 | 1 | Number of the Event DUD. | | | | | |
| IXLTDT | 1 | 1 | Number of the Event LATEDT. | | | | | |
| IXLTSP | 1 | 1 | Number of the Event LATESP. | | | | | |
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| . u | | | | | | | | |

Common block name GUIDCH . Sizes: Full 356*, Reduced 192*

| Parameter | Dimen | sions | |
|-----------|-------|-----------------|--|
| Name | Ful1 | Red. | Description |
| JGCGRP | 32* | 8* | Packed list of integer parameters for up to IGCGMX guidance channel groups. |
| JBITS1 | 1 | 1 | The number of bits required to store the information in JGCGRP for one guidance channel group |
| KGCA | 96* | 96* | Packed list containing the constraint matrix, A for up to NGCTMX guidance channel group types. |
| KBITS1 | 1 | 1 | The number of bits required to store the constraint matrix, A, in KGCA for one guidance channel group type. |
| KGCPC | 32* | 32 [*] | Packed list containing the constraint vectors, P and C, for up to NGCTMX guidance channel group types. |
| KBITS2 | 1 | 1 | The number of bits required to store up to 8 values of P and 8 values of C in KGCPC for one guidance channel group type. |
| KGUID | 187* | 47* | Packed list of integer parameters for up to IGCMAX guidance channels. |
| KBITS3 | 1 | 1 | The number of bits required to store the information in KGUID for one guidance channel. |
| NGCTYP | 4 | 4* | Packed list of integer parameters for up to NGCTMX guidance channel group types. |
| NBITS3 | 1 | 1 | The number of bits required to store the information in NGCTYP for one guidance channel group type. |
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^{*} These figures are based upon a machine word length of 60 bits.

| Common block | name | 10 | Sizes: | Full | 7. | Reduced | 7 |
|------------------------|------|----|--------|------|----|---------|---|
| O O III III D I O O II | | | | | | | |

| Parameter | Dimen | sions | | | | | | | |
|-----------|-------|-------|--|--|--|--|--|--|--|
| Name | Full | Red. | Description | | | | | | |
| LINES | 1 | 1 | A counter for the number of lines that have been printed on the current page of output listing. | | | | | | |
| NPAGE | 1 | 1 | The number of the current page being printed in the input summary. | | | | | | |
| NPRINT | 1 | 1 | The logical unit number of the printer (assigned the value 6 by the INITLZ routine). | | | | | | |
| NREADR | 1 | 1 | The logical unit number of the card reader (assigned the value 5 by the INITLZ routine). | | | | | | |
| NRTAPE | 1 | 1 | The logical unit number of the type-replication binary data tape, the first file of which contains type data and succeeding files contain replication data for games that have been defined. | | | | | | |
| N20BCD | 1 | 1 | The number of words being used to store a 20 character alphanumeric field. The value of N2OBCD is 2 for a 60-bit word machine such as the CDC 6400 and a 2A10 format is used. | | | | | | |
| NSWICH | 1 | 1 | A switch used to control the printing of headings and page numbering. | | | | | | |
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|--------|-------|------|--------|---|--------|------|----|-----------|----|
| Common | block | name | LAUNCH | • | Sizes: | Full | 82 | , Reduced | 29 |

| Description | | | | | |
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^{*}These figures are based upon a machine word length of 60 bits.

Common block name LCHSEC . Sizes: Full 378 , Reduced 90

| Parameter | Dimensions | | | | | | | |
|-----------|------------|------|--|--|--|--|--|--|
| Name | Full | Red. | Description | | | | | |
| RSECTL | 63 | 15 | Right hand boundary of fire zone sector for each of ILMAX launchers. | | | | | |
| WI DEL | 63 | 15 | Width of the fire zone sectors. | | | | | |
| COSRTL | 63 | 15 | Cosine of the right hand fire zone sector boundary angle. | | | | | |
| SINRTL | 63 | 15 | Sine of the right hand fire zone sector boundary angle. | | | | | |
| COSLFL | 63 | 15 | Cosine of the left hand fire zone sector boundary angle. | | | | | |
| SINLFL | 63 | 15 | Sine of the left hand fire zone sector boundary angle. | | | | | |
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| Common | block | name | MAXES | Sizes: | Ful1 | 20 | . Reduced | 20 |
|--------|-------|------|-------|--------|------|----|-----------|----|
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| Parameter | Dimensions | | Description | | | |
|----------------|------------|------|--|--|--|--|
| Name Full Red. | | Red. | | | | |
| IGCGMX | 1 | 1 | Maximum number of guidance channel groups allowable; determines the dimension of packed list JGCGRP. | | | |
| IGCMAX | 1 | 1 | Maximum number of guidance channels allowable; determines the dimension of packed list KGUID. | | | |
| IGCTOP | 1 | 1 | The number of guidance channels actually generated in the Defense Generator; must be ≤ IGCMAX. | | | |
| ILMAX | 1 | 1 | Maximum number of missile launchers allowable; determines the dimension of packed list LAUNFO and of all arrays in common block LCHSEC. | | | |
| ILTOP | 1 | 1 | The number of missile launchers actually generated in the Defense Generator; must be ≤ ILMAX. | | | |
| IRMAX | 1 | 1 | Maximum number of radar sets allowable; determines the dimensions of packed lists IRADPC and IDETPC, and of all arrays in common block RADSEC. | | | |
| IRTOP | 1 | 1 | The number of radar sets actually generated in the Defense Generator; must be ≤ IRMAX. | | | |
| ISMAX | 1 | 1 | Maximum number of defense units (ships) allowable; determines the dimensions of packed lists ISHPFO, ICOMM, and IMODIF and of array SHIPOS in common block SHIP, and of array FDETM in common block TECOMM. | | | |
| ISTOP | 1 | 1 | The highest numbered defense unit actually generated in the Defense Generator; must be ≤ ISMAX. | | | |
| JTMAX | 1 | 1 | Maximum number of offense units (launch vehicles and parasites) allowable; determines the dimensions of packed lists JTRGFO, JSTAR, and IDETPC and of array DISP and all floating point arrays in common block TRGDTA. | | | |
| JTTOP | 1 | 1 | The total number of offense units actually generated in the Raid Generator (same value as JTGT in common block TARGET); must be ≤ JTMAX. | | | |

Continued on next page

Common block name

MAXES (Continued)

| Parameter | Dimen | sions . | | | | | |
|----------------|-------|---------|---|--|--|--|--|
| Name Full Red. | | Red. | Description | | | | |
| JWPMAX | 1 | 1 | Maximum number of (parasite) weapon profiles allowable; determines the dimension of packed list JWPRF. | | | | |
| NECMAX | 1 | 1 | Maximum number of ECM loading groups allowable; determines the dimension of packed list NECMGP. | | | | |
| NGCTMX | 1 | 1 | Maximum number of guidance channel group types allowable; determines the dimensions of packed lists KGCA, KGCPC, and NGCTYP. | | | | |
| NLTMAX | 1 | 1 | Maximum number of missile launcher types allowable; determines the dimensions of packed list LCHPAR. | | | | |
| NMTMA X | 1 | 1 | Maximum number of missile types allowable; determines the dimensions of packed lists MSLPAR and MSLPK and of all floating point arrays in common block MISSL. | | | | |
| NRTMAX | 1 | 1 | Maximum number of radar types allowable; determines the dimensions of packed lists IRDRPC and IRADPC and of array RC in common block RADAR. | | | | |
| NSTMAX | 1 | 1 | Maximum number of ship types allowable; determines the dimensions of packed lists KRSHPT, MNSHPT, NPSHPT, and NVSHPT. | | | | |
| NTTMAX | 1 | 1 | Maximum number of target types (launch vehicles and parasites) allowable; determines the dimension of packed list NTGPAR. | | | | |
| NCSGMX | 1 | 1 | Maximum number of target cross section groups; determines the dimension of packed list NCSGRP and floating point array CSDATA. | | | | |
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Common block name MAXES (Concluded)

| Parameter | Dimen | sions | | | | | | |
|-----------|-----------|-------|---|--|--|--|--|--|
| Name | Full Red. | | Description | | | | | |
| ICOMAX | 1 | 1 | Maximum number of ship-type components allowable; determines the dimensions of packed lists IBOLFN, NBOVAR, and NSTCOM. | | | | | |
| NCTMAX | 1 | 1 | Maximum number of component types allowable; determines the dimensions of packed list ICTPAR. | | | | | |
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Common block name MISSL . Sizes: Full 1093 , Reduced 1093

| Parameter | Dimensions | | | | | |
|-----------|-----------------|--------|---|--|--|--|
| Name | Full | Red. | Description | | | |
| MSLPAR | 7* | 7* | Packed list of integer parameters for up to NMTMAX missile types. | | | |
| MBITS2 | 1 | 1 | The number of bits required to store information in MSLPAR for one missile type. | | | |
| MSLPK | 79 [*] | 79* | Packed list of missile lethality data for up to NMTMAX missile types. | | | |
| MBITS3 | 1 | 1 | The number of bits required to store (P_k,μ,σ) for up to 15 vulnerability groups for a single missile type. | | | |
| PRFENV | 2,9,15 | 2,9,15 | Floating point array of nodes describing the performance envelope for each missile type; since the first node is assumed to be at $(0,0)$, its storage location is utilized to store the values of R_{min} and R_{max} . | | | |
| TOF | 7,7,15 | 7,7,15 | Floating point array containing the time of flight data matrix; as many as 7 rows and 7 columns for each missile type may be accommodated. | | | |
| | | | | | | |

^{*} These figures are based upon a machine word length of 60 bits.

Common block name MPARAM . Sizes: Full 6*, Reduced 6*

| Parameter | Dimen | sions | | | | | |
|-----------|-------|-------|---|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| Р | 3 | 3 | Scratch storage used target position in event IMPACT. | | | | |
| v | 3 | 3 | Scratch storage used for target velocity in event IMPACT. | | | | |
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^{*}These figures are based upon a machine word length of 60 bits.

Common block name NAMES . Sizes: Full 466[†] , Reduced 418[†]

| Parameter | Dimen | sions | Description | | | | |
|-----------|--------------------|--------------------|---|--|--|--|--|
| Name | Full Red. | | Description | | | | |
| FLCTNM | 2 [†] ,15 | 2 [†] ,15 | 20 character name field for up to NLTMAX launcher types. | | | | |
| FMSTNM | 2 [†] ,15 | 2 [†] ,15 | 20 character name field for up to NMTMAX missile types. | | | | |
| GCGTNM | 2 [†] ,15 | 2 [†] ,15 | 20 character name field for up to NGCTMX guidance channel group types. | | | | |
| RDRTNM | 2 [†] ,31 | 2 [†] ,31 | 20 character name field for up to NRTMAX radar types. | | | | |
| RUNID | 2 [†] | 2 [†] | 20 character run identification field taken from the game control card (the contents of this array are written as the first record on the replication data file). | | | | |
| SHIPNM | 2,31 | 2 [†] ,7 | 20 character name field for up to ISMAX defense units or ships. | | | | |
| SHPTNM | 2 [†] ,31 | 2 [†] ,31 | 20 character name field for up to NSTMAX ship types. | | | | |
| TGTNM | 2 [†] ,31 | 2 [†] ,31 | 20 character name field for up to NTTMAX target types. | | | | |
| CMPTNM | 2 [†] ,63 | 2 [†] ,63 | 20 character name field for up to NCTMAX component types. | | | | |
| | | | | | | | |

[†]The first dimension of an alphanumeric array corresponds to the number of machine words being used to store 20 characters (see N20BCD in common block IO).

| Common | block | name | NEXTUP | <u>.</u> . | Sizes: | Full | 5, | Reduced | 5 |
|--------|-------|------|--------|------------|--------|------|----|---------|---|
|--------|-------|------|--------|------------|--------|------|----|---------|---|

| Parameter | Dimen | sions | | | | | | |
|-----------|-----------|-------|---|--|--|--|--|--|
| Name | Full Red. | | Description | | | | | |
| SIMTIM | 1 | 1 | Game simulation time (i.e., time of the next event). | | | | | |
| NEVENT | 1 | 1 | Event type number of the next event. | | | | | |
| IEVENT | 1 | 1 | First integer parameter associated with the next event. | | | | | |
| JEVENT | 1 | 1 | Second integer parameter associated with the next event. | | | | | |
| KLNGTH | 1 | 1 | Current length of the event calendar (same value as LENCAL in common block CALNDR). | | | | | |
| | | | | | | | | |

Common block name OPTION . Sizes: Full 52 , Reduced 52 .

| Parameter | Dimensions | | | | | | |
|-----------|------------|------|---|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| ENDM | 1 | 1 | Ending time of event monitoring time interval. | | | | |
| MDETAL | 1 | 1 | Detailed prereplication listing indicator where (0) = no printout, (1) = first replication only, and (2) = all replications. | | | | |
| MENDEL | 1 | 1 | Controls printing of entries and deletions where (0) = no printout, (1) = first replication only, and (2) = all replications. | | | | |
| MEVENT | 1 | 1 | Indicates whether event occurrences are to be printed for the first replication only (1), for all replications (2), or not at all (0). | | | | |
| MEVPRT | 45 | 45 | Indicates whether occurrences of each event type are to be printed (1) or not printed (0). May be overridden by MEVSET, below. | | | | |
| MEVSET | 1 | 1 | Controls printing of event occurrences where (0) means none are to be printed, (1) = all and (2) = some as specified by MEVPRT() above. | | | | |
| NWPREM | 1 | 1 | The number of impacting targets remaining at the current simulation time. | | | | |
| STARTM | 1 | 1 | Starting time of event monitoring time interval. | | | | |
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|--------|-------|------|-------|--------|------|-----|---|---------|-----|--|
| Common | block | name | RADAR | Sizes: | Full | 378 | , | Reduced | 354 | |
| | | | | | | | | | | |

| | Dimens | sions | | | | | |
|-------------------|---------|--------|--|--|--|--|--|
| Parameter Name | Full | Red. | Description | | | | |
| IRADPC | * 32 | * 8 | Packed list of integer parameters for up to IRMAX radar sets. | | | | |
| IBITS2 | 1 | 1 | The number of bits required to store the information in IRADPC for one radar set. | | | | |
| IRDRPC | 19* | 19* | Packed list of integer parameters for up to NRTMAX radar types. | | | | |
| івітѕ3 | 1 | 1 | The number of bits required to store the information in IRDRPC for one radar type. | | | | |
| IRDROP | 45* | 45* | Packed list containing radar simulation model integer parameters for up to NRTMAX radar type | | | | |
| IBITS4 | 1 | 1 | The number of bits required to store the option information in IRDROP for one radar type. | | | | |
| RC | 8,31 | 8,31 | Array of as many as 8 floating point parameter for up to NRTMAX radar types. | | | | |
| XLMDA | 31 | 31 | Normalized threshold used in probability of detection computation. | | | | |
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^{*} These figures are based upon a machine word length of 60 bits.

Common block name RADSEC . Sizes: Full 441 , Reduced 105

| Parameter | Dimen | sions | |
|-----------|-------|-------|--|
| Name | Full | Red. | Description |
| RSECT | 63 | 15 | Right hand boundary of coverage sector for each of up to IRMAX radar sets. |
| WIDE | 63 | 15 | Width of the radar coverage sectors. |
| COSRT | 63 | 15 | Cosine of the right hand coverage sector boundary angle. |
| SINRT | 63 | 15 | Sine of the right hand coverage sector boundary angle. |
| COSLF | 63 | 15 | Cosine of the left-hand coverage sector boundary angle. |
| SINLF | 63 | 15 | Sine of the left-hand coverage sector boundary angle. |
| RZROOT | 63 | 15 | Square root of the radar set antenna height. |
| | | | |

| Common block name | RAID | Sizes: | Full | 4, | Reduced | 4 |
|-------------------|------|--------|------|----|---------|---|
| | | | | | | |

| Parameter | Dimen | sions | | | | | |
|-----------|-------|-------|--|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| JPATH | 1 | 1 | A pointer to the next available cell within the PATHS array; used within the raid generator routines. | | | | |
| MFPL | 1 | 1 | The number of legs in the MFP currently being used within RAIDGN. | | | | |
| MFPX | 1 | 1 | A pointer to the X-coordinate of the first node of the MFP currently being used within RAIDGN. | | | | |
| TMXMFP | 1 | 1 | The latest time at which any MFP node is to occur, according to the inputs to RAIDGN (exclusive of parasite node times). | | | | |
| | | | | | | | |

Common block name RANDOM . Sizes: Full 74 , Reduced 74 .

| Parameter Dimensions | | sions | |
|----------------------|------|-------|--|
| Name | Full | Red. | Description |
| М | 1 | 1 | Modulus of the x and y linear congruential sequences used in the generation of uniformly distributed random numbers. |
| FM | 1 | 1 | The floating point representation of the modulus above. |
| IM | 1 | 1 | м/64 |
| IW | 1 | 1 | 2 ⁵⁹ -1; the largest integer a machine word will hold.* |
| IX | 1 | 1 | Current integer value in the x congruential sequence. |
| A1 | 1 | 1 | Multiplier for the x congruential sequence. |
| C1 | 1 | 1 | Increment for the x congruential sequence. |
| IY | 1 | 1 | Current integer value in the y congruential sequence. |
| A2 | 1 | 1 | Multiplier for the y congruential sequence. |
| C2 | 1 | 1 | Increment for the y congruential sequence. |
| IR | 64 | 64 | Random number table. |
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Notes:

*These figures are based upon a machine word length of 60 bits.

Common block name RDRSMR . Sizes: Full ______, Reduced __24

| Parameter | Dimensions | | | | | | |
|-----------|------------|------|---|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| RNGERR | | 6 | A 3 x 2 array where row 1 contains the minimum radar range error in kft along with the time of occurrence, row 2 the maximum and its time of occurrence, and row 3, column 1 the total range error. | | | | |
| AZMERR | | 6 | A 3 x 2 array where row 1 contains the minimum radar azimuth error in mils along with the time of occurrence, row 2 the maximim and its time of occurrence, and row 3, column 1 the total azimuth error. | | | | |
| RDRERR | | 6 | A 3 x 2 array where row 1 contains the minimum net radar error in kft along with the time of occurrence, row 2 the maximum and its time of occurrence, and row 3, column 1 the total net radar error. | | | | |
| POSERR | | 6 | A 3 x 2 array where row 1 contains the minimum track symbol to video distance in kft along with the time of occurrence, row 2 the maximum and its time of occurrence, and row 3, column 1 the total track symbol to video distance. | | | | |
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| Common | block | name | REP | Sizes: | Full | 7, | Reduced | 7 |
|--------|-------|------|-----|--------|------|----|---------|---|
| | | | | | | | | |

| Parameter | Dimen | sions | | | | | |
|-----------|-------|----------------|--|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| MREP1 | 1 | 1 | Option for printing a detailed replication summary for the first replication only (0) or for all replications (1). | | | | |
| NREP | 1 | 1 | Number of the replication currently being played. | | | | |
| NREPS | 1 | 1 | The highest numbered replication to be played. | | | | |
| NREP1 | 1 | 1 | The number of the first replication to be played (one greater than the number of replications previously played). | | | | |
| REPID | 2+ | 2 [†] | 20 character identification of the game. | | | | |
| NSCRCH | 1 | 1 | The logical unit number of the scratch file containing replication data for the game. currently being played. | | | | |
| | | | | | | | |

The dimension of this alphanumeric array corresponds to the number of machine words being used to store 20 BCD characters.

| Common | block | name | RSET | Sizes: | Ful1 | , Reduced | i 10 |
|--------|-------|------|------|--------|------|-----------|------|
| | | | | | | | |

| Parameter Dimensions Name Full Red. | | sions | | |
|-------------------------------------|-----|-------|---|--|
| | | Red. | Description | |
| COSTHT | | 1 | The cosine of the angle* of rotation. Applicable only if the reachable set is an ellipse. | |
| SINTHT | | 1 | The sine of the angle of rotation. Applicable only if the reachable set is an ellipse. | |
| BSQ | | 1 | Computed as $1.0 - E^2$ where E is the eccentricity of the ellipse. Applicable only if the reachable set is an ellipse. | |
| MRSOPT | | 1 | Indicates the form of the reachable set where 1 means a circle and 2 an ellipse. | |
| RADSQ | | 1 | The square of the radius limiting the size of the reachable set. | |
| SFACTR | | 5 | An array of 5 scale factors which are used to increase or decrease the size of the reachable set. The factors are a function of the number of reports in the track history. | |
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 $[\]star e.g.$, the angle between the X-axis and the current flight path leg of of the target under consideration.

| Common | block nar | ne SHIP | | Sizes: | Full | 535 | Reduced | 401* |
|--------|-----------|---------|---|--------|-------|-----|---------|------|
| Common | DIOON Nu | | · | DIECE. | 1 411 | | neaucea | |

| Parameter | Dimen | sions | | | | | |
|-----------|-------------|---------|--|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| I SHPFO | * 49 | * 11 | Packed list of integer parameters for up to ISMAX ships. | | | | |
| IBITS5 | 1 | 1 | The number of bits required to store information in ISHPFO for one ship. | | | | |
| KRSHPT | 19* | 19* | Packed list containing radar types for up to NSTMAX ship types. | | | | |
| KBITS4 | 1 | 1 | The number of bits required to store information in KRSHPT for a maximum of 7 radar sets for a single ship type. | | | | |
| MNSHPT | 163* | 163* | Packed list of guidance-channel-group integer parameters for up to NSTMAX ship types. | | | | |
| MBITS1 | 1 | 1 | The number of bits required to store infor- mation in MNSHPT for a maximum of 7 guidance- channel groups for a single ship type. | | | | |
| NPSHPT | 20 * | 20* | Packed list of integer parameters for up to NSTMAX ship types. | | | | |
| NBITS4 | 1 | 1 | The number of bits required to store information in NPSHPT for one ship type. | | | | |
| NVSHPT | 155* | 155* | Packed list of component position and vulner-ability data for up to NSTMAX ship types. | | | | |
| NBITS6 | 1 | 1 | The number of bits required to store information in NVSHPT for up to 10 component groups for a single ship type. | | | | |
| SHIPOS | 3,31 | 3,7 | Array of position coordinates (X,Y,Z) for up to ISMAX ships. | | | | |
| I NRNG | 31 | 7 | Array of in-range target counters for up to ISMAX ships. | | | | |
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^{*} These figures are based upon a machine word length of 60 bits.

Common block name SHPTYP . Sizes: Full 194 , Reduced 194 .

| Parameter Dimensions Name Full Red. | | sions | |
|-------------------------------------|------|-------|---|
| | | Red. | Description |
| KRSHPT | 19* | 19* | Packed list containing radar types for up to NSTMAX ship types. |
| KBITS4 | 1 | 1 | The number of bits required to store information in KRSHPT for a maximum of 7 radar sets for a single ship type. |
| KTSHPT | . 9* | 9* | Packed list containing radar and scope limit assignments for the track supervisor and tracking operators aboard this ship type. |
| KBITS5 | 1 | 1 | The number of bits required to store information in KTSHPT for a maximum of 7 radar and scope limit assignments for a single ship type. |
| MNSHPT | 163* | 163* | Packed list of guidance channel group integer parameters for up to NSTMAX ship types. |
| MBITS1 | 1 | 1 | The number of bits required to store information in MNSHPT for a maximum of 7 guidance channel groups for a single ship type. |

^{*}These figures are based upon a machine word length of 60 bits.

Common block name SRVTIM .

Sizes: Full _____, Reduced __18

| Parameter | Dimens | sions | |
|----------------|--------|-------|--|
| Name | Full | Ređ. | Description |
| MSRVTS | | 2 | The minimum and maximum mean value service times for the track supervisor. |
| MSRVDT | | 14 | $A\ 2\ x\ 7$ array of minimum and maximum mean value service times for each of up to 7 tracking operators. |
| J CMISS | | 1 | The number of consecutive missed reports necessary to initiate drop track action. |
| RSMAX | | 1 | The maximum allowable reachable set radius or major axis in kft. |
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| Common | block | name | SUMMRY | Sizes: | Ful1 | 936 . | Reduced | 226 | |
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| Parameter | Dimer | sions | |
|-----------|-------|------------|---|
| Name | Full | Red. | Description |
| RMINL | 63 | 15 | Min. intercept range achieved by each launcher. |
| RMAXL | 63 | 15 | Max. " " " " " . |
| AMINL | 63 | 15 | Min. intercept altitude " " " . |
| AMAXL | 63 | 15 | Max. " " " " " . |
| RSUML | 63 | 15 | Sum of all intercept ranges for each launcher. |
| ASUML | 63 | 15 | Sum " " altitudes " " " . |
| RMINR | 63 | 15 | Min. detection range achieved by each radar set |
| RMAXR | 63 | 15 | Max. " " " " ". |
| RSUMR | 63 | 15 | † Sum of all detection ranges for each radar set. |
| PMINR | 63 | 15 | Min. probability of detection (at target detection event) for each radar set. |
| PMAXR | 63 | 15 | Max. probability of detection, as above. |
| PSUMR | 63 | 15 | Sum [†] of all detection probabilities for each radar set. |
| JTOUT | 179* | 4 5 | Packed list of output summary information for each target. |
| ЈВІТЅ5 | 1 | 1 | The number of bits required to store the information in JTOUT for one target. |
| | | | |

 $^{^{\}star}$ These figures are based upon a machine word length of 60 bits.

At the completion of a replication, the sum is divided by the number of occurrences to obtain the average value.

Common block name SUNS . Sizes: Full 1530 , Reduced 378

| Parameter | Dimen | sions | | | | | |
|-----------|-------|-------|---|--|--|--|--|
| Name | Full | Red. | Description | | | | |
| MSUNV | 255 | 63 | Array of vertical angle resolution numbers for each target with respect to a particular radar under consideration; may be used as a temporary storage array by routines not associated with radar simulation. | | | | |
| MSUNH | 255 | 63 | As above for horizontal angle resolution. | | | | |
| MSUNR | 255 | 63 | As above for range resolution. | | | | |
| MSUNC | 255 | 63 | As above for closing speed resolution. | | | | |
| IDSTAT | 255 | 63 | Array used to indicate current detection status and eligibility for consideration of each target with respect to a particular radar under consideration; may also be used for temporary storage. | | | | |
| JMSTAT | 255 | 63 | Array used to store the jamming power density of each appropriate target (e.g., above the radar horizon) on the frequency band of a particular radar under consideration; may also be used for temporary storage. | | | | |
| | | | | | | | |

Common block name TARGET . Sizes: Full $2113^{*\dagger}$, Reduced $497^{*\dagger}$. $2137\ddagger$ 421 \ddagger

| | | | 2137‡ 421‡ | | | | |
|-----------|-------------------|-------------|--|--|--|--|--|
| Parameter | Dimen | sions | | | | | |
| Name | Ful1 | Red. | Description | | | | |
| DISP | 3,255 | 3,63 | Array of target displacements ($\Delta X, \Delta Y, \Delta Z$) from the associated master flight paths. | | | | |
| ENDGTM | 1 | 1 | The latest target node time from which parasite launches are referenced or, if there are no parasites, the latest node time of any target. | | | | |
| JPAR | 1 | 1 | The total number of parasite targets specified in the RAIDGN inputs. | | | | |
| JTGT | 1 | 1 | The total number of targets, including parasites, specified in the RAIDGN inputs. | | | | |
| JTRGFO | 319* | 7 9* | Packed list of integer parameters for up to JTMAX targets. | | | | |
| JBITS3 | 1 | 1 | The number of bits required to store information in JTRGFO for a single target. | | | | |
| JWPRF | 8* | 8* | Packed list of integer parameters for up to JWPMAX weapon profile descriptions. | | | | |
| JBITS4 | 1 | 1 | The number of bits required to store information in JWPRF for one weapon profile. | | | | |
| NTGPAR | 14* | 14* | Packed list of integer parameters for up to NTTMAX target types. | | | | |
| NBITS5 | 1 | 1 | The number of bits required to store information in NTGPAR for one target type. | | | | |
| LPATH | 1 | 1 | Dimension [†] of the PATHS array. | | | | |
| PATHS | 1000 [†] | 200 | Array of master flight path and weapon profile data. | | | | |
| JTFAIL | | 23 | Packed list of failure probabilities for up to JTMAX targets. | | | | |
| JBITS7 | | 1 | The number of bits required to store the failure probabilities in JTFAIL for one target. | | | | |
| | | | | | | | |

 $^{^{*}}$ These figures are based upon a machine word length of 60 bits.

[†]The dimension of the PATHS array is set arbitrarily; generation of numerous and lengthy MFPs and weapon profiles would necessitate increasing the dimension of this array.

[‡]These sizes include the storage unique to the TDHS version.

Common block name TECOMM . Sizes: Full 332*, Reduced 84*

| Parameter | Dimen | sions | | | | |
|-------------------------|-------|-------|--|--|--|--|
| Name | Full | Red. | Description | | | |
| ICOMM | 17* | 1* | Packed list of intership-communication-link status values. | | | |
| IBITS6 | 1 | 1 | The number of bits required to store the communications link status data in ICOMM for one ship (receiver). | | | |
| IXMIT | 1 | 1 | An indicator that will override use of the ICOMM list if not equal to 0. If < 0, then no links ever exist; if > 0, then all links always exist. | | | |
| I MOD I F | 17* | 1* | Packed list specifying which intership communications links are allowed to be modified by the effects of enemy jamming. | | | |
| IBITS7 | 1 | 1 | The number of bits required to store the modification specifications in IMODIF for one ship (receiver). | | | |
| MODIFY | 1 | 1 | An indicator that will override use of the IMODIF list if not equal to 0. If < 0, then no links are allowed to be modified; if > 0, then all links are allowed to be modified. | | | |
| COMDLY | 1 | 1 | Intership_communications time delay (seconds). | | | |
| FDETM | 31 | 7 | Time at which the first target detection takes place by each of ISTOP ships; used to trigger subsequent TEWA events. | | | |
| TEDLY | 1 | 1 | Time delay from first target detection to earliest possible weapon assignment (seconds). | | | |
| MTHRT | 255 | 63 | Target threat number list, made up and used within the TEWA routine. | | | |
| VAC | 2 | 2 | Vital Area Center position coordinates (X, Y). | | | |
| THRES | 4 | 4 | Range squared threshold values used to determine the range parameter of a target's threat number. | | | |
| | | | | | | |

^{*} These figures are based upon a machine word length of 60 bits.

| Common | block | name | TIMCHK | • | Sizes: | Ful1 | . 60 | . Reduced | 60 |
|--------|-------|------|--------|---|--------|------|------|-----------|----|
| | | | | | | | | | |

| Parameter | Dimensions | | | | | | |
|-----------|------------|------|--|--|--|--|--|
| Name | Ful1 | Red. | Description | | | | |
| TOLER | 60 | 60 | The tolerance, by event type, within which the time of a scheduled event must agree with a designated time in order for the former to be canceled from the calendar by routine CANCEL. | | | | |
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| Common | block | name | TIMES | Sizes: | Full | 515 | , Reduced | 131 | |
|--------|-------|------|-------|--------|------|-----|-----------|-----|---|
| | | | | | _ | | . • | | _ |

| Parameter | Parameter Dimensions Name Full Red. | | | |
|-----------|-------------------------------------|----|---|--|
| Name | | | Description | |
| ABRTM | 1 | 1 | The time delay between the decision to abort a launched missile and the occurrence of the abort. | |
| ASGNTM | 255 | 63 | The assignment time of a guidance channel's currently held assignment. | |
| ENDTIM | 1 | 1 | End of play time computed by the simulation program. If there are no parasites, ENDTIM is equal to ENDGTM (see common block TARGET). If there are parasites, when time ENDGTM is reached a check is made to see if there are active parasites remaining. If there are, ENDTIM is equal to the latest impact time; if there are not, ENDTIM is ENDGTM. | |
| GAMTMX | 1 | 1 | End of play time specified on the game parameter card. | |
| RELTM | 255 | 63 | The release time of a guidance channel from its currently held assignment. | |
| TEWADT | 1 | 1 | The time between successive TEWA events for a ship group. | |
| TINF | 1 | 1 | Variable representing a time of positive infinity (arbitrarily assigned a value of 10^{20}). | |
| | · | | | |

Common block name

TRACK

Sizes: Full

_____, Reduced _

1637 .

| Parameter | Dimens | sions | | | |
|-----------|--------|-------|---|--|--|
| Name | Ful1 | Red. | Description | | |
| JREPRT | | 51 | Packed list of integer parameters for up to JMAXTK (below) tracks. | | |
| JBITS6 | | 1 | The number of bits required to store the information in JREPRT for one track. | | |
| SYMBLS | | 126 | A 2 x 63 array used to store the X and Y coordinates corresponding to the track symbol position as computed from the most recent updating of the track symbology. | | |
| TSUD | | 1 | The time at which the track symbology was most recently updated. | | |
| REPRTS | | 945 | A 3 x 5 x 63 array of track history data where the first dimension corresponds to the X , Y coordinates of the symbol position along with the time the position was recorded, the second dimension is for storing the 5 most recent updatings of the symbol position and the third dimension corresponds to the track number. | | |
| FIT | · | 315 | A 5 x 63 array of information derived by performing a least-squares fit on the position reports held for each track. The 5 values stored for each track are: (1-2) the X and Y coordinates obtained by dropping a perpendicular from the most recent position report to the regression line, (3-4) the velocity components of the track in the X and Y direction, and (5) the speed of the track. | | |
| JFIRM | | 1 | The number of reports required to advance a track from tentative to firm status. | | |
| MAXRPS | | 1 | The maximum number of position reports on a track that can be stored in the array REPRTS. | | |
| MAXRM1 | | 1 | The value MAXRPS minus one. | | |
| IDEXTL | | 1 | The external identification number (used for output) of the most recently established track. | | |
| IDTRK | | 126 | A 2 x 63 array containing two items for each track. The first is the external identification number associated with the track (zero if the track has been dropped), and the second the reporting radar for the most recent report, along | | |

Common block name TRACK (Concluded).

| Parameter | | | |
|-----------|------|------|--|
| Name | Full | Red. | Description |
| | | | with the number of reports at track establishment (packed as the reporting radar plus 1024 times the number of reports). |
| JTKTOP · | | 1 | The internal track number (used an an index) of the most recently established track. |
| JMAXTK | | 1 | The maximum number of tracks that can be active during play of a game. |
| TSERV | | 63 | An array of times representing the time at which servicing of each track was most recently completed. |
| TIMINUP | | 1 | The minimum time in seconds between attempts to update a given track. |
| PCTNEW | | 1 | The percent by which a candidate track speed must differ from a reference track speed to call it a new track rather than a split from the reference track. |
| JDEG | | 1 | The degree of the least-squares fit of the track history data. |
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Common block name TRGDTA Sizes: Full 4362*, Reduced 978*

| Parameter Name | Dimensions | | |
|-------------------|------------|------|---|
| | Full | Red. | Description |
| АРНТ | 255 | 63 | Apparent height above the radar horizon, in kft, for each target with respect to a particular radar set. |
| ASPECT | 255 | 63 | Horizontal aspect angle of each target with respect to a particular radar set. |
| CVEL | 255 | 63 | The scalar closing speed of each target with respect to a particular radar set. |
| DIE | 255 | 63 | The time at which each target is currently due to die from the effects of defensive weapon intercepts. |
| RANGE | 255 | 63 | The slant range from each target to a particular radar set. |
| HRZANG | 255 | 63 | The horizontal angle to each target from a particular radar set (in radians, CCW from the +X axis). |
| FNHORZ | 255 | 63 | The horizontal offaxis antenna pattern function value with respect to a particular radar, when attempting to detect a specified target. |
| VRTANG | 255 | 63 | The vertical angle to each target from a particular radar set (in radians above the radar horizon). |
| FNVERT | 255 | 63 | The vertical offaxis antenna pattern function value with respect to a particular radar, when attempting to detect a specified target. |
| POS | 3,255 | 3,63 | The (current) position of each target (X,Y,Z). |
| VEL | 3,255 | 3,63 | The (current) velocity of each target (V, V, V). x, y, z |
| I DETPC | * 536 | 32* | Packed list of the detection status of each target with respect to each radar set. The dimension of this list is derived from the product of JTMAX and IRMAX. |
| IBITS1 | 1 | 1 | The number of bits required to store information in IDETPC for one radar. The value of IBITS1 is equal to 2 times JTMAX. |
| | | | |

^{*} These figures are based upon a machine word length of 60 bits.

| Commor | . h1 | 0012 | n ama |
|--------|------|------|-------|
| COMMO | 1 DI | OCK | name |

TRKCOL .

Sizes: Full ______, Reduced __63

| Parameter | Name Dimensions Full Red. | | | | |
|-----------|---------------------------|----|---|--|--|
| | | | Description | | |
| JTKCOL | | 63 | The ith entry in this array contains the track number which corresponds to the (i+1)th column of the videotrack correlation score array, COR.* This data allows the track supervisor to utilize the correlation and assignment information generated within the detector/tracker routine. | | |
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Notes:

^{*}The COR array is in common block VIDTRK.

| Parameter | Dimen | sions | |
|---------------|-------|-------|--|
| Name | Full | Red. | Description |
| NLATES | | 1 | The number of late detections recorded in the play of a game. |
| RLATE | | 1 | The square of the range used to determine when a detection is a late detection. |
| NSEQOP | | 1 | The total number of times all tracking operators are sequenced to tracks. |
| <i>JMINUP</i> | | 1 | The minimum number of updates performed on a track. |
| <i>JMAXUP</i> | | 1 | The maximum number of updates performed on a track. |
| TE1ST | | 1 | The time at which the first track is established. |
| TPREVT | · | 1 | The time of the most recent establishment or dropping of a track. |
| ATRKTM | | 1 | Each time a track is established or dropped, the number of currently active tracks is multiplied by the time period (current time minus TPREVT) over which this number was active. The value of this variable represents the total of all such products during a play of a game and is used to compute the average number of concurrently active tracks. |
| JATMAX | | 1 | The maximum number of active tracks held during the play of a game. |
| TBUOP | | 3 | The minimum, maximum, and total time, respectively, between updates with respect to any operator. The time between updates represents the time between completion of the current service operation and the time the immediately previous service operation by this operator was completed. |
| TBUTK | | 3 | The minimum, maximum, and total time, respectively, between updates with respect to all tracks that have been established. The time between updates represents the time between completion of the current service operation and the time servicing of this track was previously completed. |
| RNGD1 | | 3 | The minimum, maximum, and total range in kft at the time of track establishment. |

| Parameter | Dimen | sions | |
|---------------|-------|-------|---|
| Name | Ful1 | Red. | Description |
| PCE | | 3 | The minimum, maximum, and total ball tab error in kft for each service operation. |
| TDUR | | 3 | The minimum, maximum, and total track duration with respect to all tracks. The duration of a track is defined as the time from establishment to the time the track is dropped or play ends. |
| TAT | , | 3 | The minimum, maximum, and total time that a track was a tentative track. A track is called tentative until it has been updated a specified number of times. The time as a tentative track is defined as the difference between video update times (1) at the time a track becomes a firm track, and (2) at the time of track establishment. |
| TMEST | | 63 | The time each track was established. For new detections, the time is stored as the most recent video update time less a scan period and for split tracks it is the most recent video update time. |
| NATRKS | | 1 | The current number of active tracks. |
| <i>JMINMS</i> | | 1 | The minimum number of missed reports on a track. |
| <i>JMAXMS</i> | | 1 | The maximum number of missed reports on a track. |
| AOPTM | | 1 | Each time a tracking operator is activated or deactivated, the number of currently active operators is multiplied by the time period (current time minus TPREVO) over which the number was active. The value of this variable represents the total of all such products during a play and is used to compute the average number of active tracking operators. |
| IAOMAX | | 1 | The maximum number of tracking operators active at any one time. |
| TPREVO | | 1 | The time of the most recent activation or deactivation of a tracking operator. |
| T1STOP | | 1 | The first time at which an operator is activated. |

Common block name TRKSMR (Concluded).

| Parameter | Dimen | sions | |
|-----------|-------|-------|--|
| Name | Full | Red. | Description |
| TIMIN | | 12 | An array of times associated with the following minimum values: (1) The time at which the minimum number of updates performed was recorded (2) The time at which the minimum number of missed reports was recorded (3) The time at which the minimum number of active tracks was recorded (corresponds to the time of first track establishment) (4) The time at which the minimum number of operators was active (corresponds to the time of first operator activation) (5) The time at which the minimum time between updates of a track occurred (see TUBTK) (6) The time at which the minimum time between updates for a tracking operator occurred (see TBUOP) (7) The time at which the minimum track establishment range occurred (8) The time at which the minimum ball tab error was recorded (9) The time at which the minimum track duration was recorded (10) The time at which the minimum time as a tentative track for new detections occurred (11) The time at which the minimum time as a tentative track for a split track occurred (12) Currently unused. |
| TIMAX | | 12 | An array of times analogous to TIMIN except for maximum values. |
| TATS | | 3 | The minimum, maximum, and total time as a tentative track for tracks established as a results of a split. |

Common block name <u>VID</u> . Sizes: Full _____, Reduced <u>257</u> .

| Parameter | Dimen | sions | |
|-----------|-------|-------|--|
| Name | Ful1 | Red. | Description |
| NVIDEO | | 1 | The number of resolved video returns obtained from the most recent updating of video. |
| RRES | | 1 | The range resolution derived from the received pulse length. |
| ARES | | 1 | The angular resolution in degrees (receiver horizontal 3 db beamwidth). |
| VIDEO | | 189 | A 3 x 63 array containing the X and Y coordinates of each of NVIDEO video returns along with the square of the range of the video to the ship. |
| JVID | | 63 | An array indicating the video return to which a target contributed (zero if the target contributed to no video return). |
| TVUD | | 1 | The time corresponding to the most recent updating of video returns. |
| SEPSQ | , | 1 | The square of the minimum distance separation in kft for multi-symbols. |
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| Common | block | name | VIDTRK | • | Sizes: | Full | , Reduced | 4097 |
|--------|-------|------|--------|---|--------|------|-----------|------|
| | | | | | | | | |

| Parameter | Dimens | sions | | | | |
|-----------|--------|-------|--|--|--|--|
| Name Full | | Ređ. | Description | | | |
| COR | | 3969 | A 63 x 63 array of correlation scores for video-track pairs where the rows correspond to video returns and the columns to active tracks. | | | |
| MCOR | | 1 | The number of rows for which there are correlation scores in the array COR. | | | |
| NCOR | | 1 | The number of columns for which there are correlation scores in the array COR. | | | |
| IASGN | | 63 | An array containing the track number to which each video return has been assigned. | | | |
| NASGN | | 63 | An array containing the number of real video returns which have been assigned to each actual track. | | | |
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Common block name

WASTE

Sizes: Full 600 , Reduced 600

| Parameter | Dimen | sions | De novê e tê e e | | | |
|-----------|---------|---------|--|--|--|--|
| Name | Full | Red. | Description | | | |
| Ü | 3 x 200 | 3 x 200 | Matrix of scratch storage used primarily in the geometrical calculations associated with event IMPACT. | | | |
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| Common | block | name | WEAPON | | Sizes: | Full | 355 | , Reduced | 355 |
|--------|-------|------|--------|---|--------|------|-----|-----------|-----|
| | | | | _ | | | | • | |

| Parameter | Parameter Dimensions | | |
|-----------|----------------------|-------|--|
| Name | Full | Red. | Description |
| LNARAY | 14,15 | 14,15 | A temporary working array of 14 integer parameters for each of up to 15 launchers on the defense unit under consideration. The parameters are obtained from packed lists LAUNFO, LCHPAR, and IRDRPC. |
| MAVL | 15 | 15 | An array, by missile type launched, of the number of launchers available for possible weapon assignment during the current TEWA interval. |
| MPRIOR | 15 | 15 | Array of missile types ordered by assignment priorities. Preference is presently given to shorter range missile types. |
| MTYPES | 1 | 1 | Number of missile types in use in the game; corresponds to the number of meaningful entries in the MPRIOR array above. |
| TALST | 15 | 15 | Ordered array of earliest possible assignment times during the current TEWA interval for launchers available on the defense unit under consideration. |
| LLIST | 15 | 15 | A list of launcher identification numbers corresponding to the time values in array TALST above. |
| NAVAIL | 1 | 1 | The total number of launchers found to be available within the current TEWA interval on the defense unit under consideration. |
| ISTATE | 10 | 10 | An array of the numbers of weapon assignments in each guidance channel state at a particular time (see Appendix G). |

Common block name WEAPON (Concluded)

| Parameter | Dimen | sions | |
|-----------|-------|-------|---|
| Name | Full | Red. | Description |
| IA | 8,8 | 8,8 | The array of coefficients (from packed list KGCA) for the guidance channel constraint group type associated with the launcher being considered for possible assignment. |
| IC | 8 | 8 | The array of constraint values (from packed list KGCA) to be associated with IA above. |
| NACTV | 1 | 1 | The number of currently active (non-disabled) guidance channels associated with the launcher being considered for possible assignment. |
| | | | |

Common block name ZBOOL* . Sizes: Full 3 , Reduced 3

| Parameter | Dimen | sions | |
|-----------|-------|-------|---------------------------|
| Name | Full | Red. | Description |
| NSN | 1 | 1 | Ship number |
| NSTN | 1 | 1 | Ship-type number |
| NSTCI | 1 | 1 | Ship-type component index |
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Notes:

 $[\]pm ZBOOL$ is used to share the subroutine BOOK variables between routines ADJUST and IBOOLE.

Appendix D

DIMENSION CHANGING PROCEDURE

Appendix D

DIMENSION-CHANGING PROCEDURE

Three categories of dimension changes will be discussed here. The three categories are: alphanumeric name arrays, packed lists, and nonpacked arrays.

Alphanumeric Name Arrays

All arrays of this type are dimensioned in the NAMES and CARDFO common blocks in the Pregame Processor and in the NAMES and REP common blocks in the Main Simulation Processor. In order to conserve memory space, it is suggested that arrays in these common blocks be dimensioned according to the number of characters that can be accommodated by a machine word. For example, the CDC 6400 has a 60-bit word, there are six bits per character, so up to 10 characters may be stored in a word. Since all name fields allow up to 20 characters of identification, two words are required for each name.

To run the program on a computer with a word size accommodating fewer than 10 characters, it is necessary to alter the dimension of all variables in the NAMES, CARDFO and REP common blocks that are dependent upon machine word size and replace the old blocks wherever they occur in the program. A list of subroutines requiring NAMES, CARDFO, and REP is included in Tables D-1 and D-3.

The variable name indicating the number of words required to store alphanumeric data is N2OBCD. This variable is assigned a value in subroutine INITLZ in the Pregame Processor and is used to control the reading, transferring, and writing of name fields. In addition to

changing alphanumeric dimensions and the value of the variable N2OBCD, it is necessary to change those FORMAT specifications used to read or write name fields. Such changes are referred to in Tables D-2 and D-4 by location of change (subroutine name) and by FORMAT statement label. Program cards that require any of the changes discussed have been denoted by punching the letter X in column 73.

Packed Lists

The equation used to compute the dimension of a packed list is as follows:

D = NB*NU/WS

where D = dimension of packed list

NB = number of bits per unit

NU = maximum number of units

WS = machine word size (number of bits)

If D is not a whole number (i.e., if NB*NU is not an even multiple of WS, replace D by the next integer value greater than D.

The dimensions established in the program at present are based upon the CDC-6400 60-bit word. If the program is to be implemented on a computer having a different word size, the dimensions of all packed lists will have to be recomputed with the above equation. To facilitate the accomplishment of this task, Table D-1 has been prepared to show all occurrences in the computer program of common blocks containing packed lists. All packed lists are described in detail in Appendices B and C. Once the dimensions of the packed lists have been redefined and incorporated in the program, the only remaining requirement is to change the second parameter (i.e., the dimension of a packed list) of calls on subroutine CLEAR found in subroutine INITLZ in the Pregame Processor.

Two additional alterations of packed lists will be discussed here. The first involves the changing of a maximum value. Suppose one wishes to increase the maximum number of ships ISMAX. All variables affected by such a change will be found in the SHIP common block. The dimensions of packed lists would have to be recomputed using the above equation, and any floating point arrays would have to be newly dimensioned. The variable ISMAX must be assigned the new value, and calls on subroutine CLEAR referencing packed lists that have been altered would have to be modified. Both the value assignment and the subroutine calls are found in the initialization routine INITLZ.

The final alteration of a packed list involves increasing or decreasing the number of bits per unit. It is suggested that, if it is desirable to increase the size of an existing field, it be treated as if it were a new field being added to the packed list. In this way a small amount of memory space will be sacrificed to minimize changes in the program. Therefore, what follows will be a discussion related to adding one or more fields to a single packed list.

Since the number of bits per unit has been increased, the common block containing the packed list will have to be newly dimensioned. As before, the appropriate call on subroutine CLEAR--found in INITLZ--must be revised. Appendix B contains complete descriptions of packed lists, including the variable name defining the number of bits per unit for each packed list. This variable name is assigned a value in subroutine INITLZ and must, of course, be assigned its new value.

The remaining and most difficult task is to find all of the packing routine (PUTBIT/GETBIT) references to the altered packed list and to make changes where it is appropriate. In order to make such changes it is necessary to know the form of calls to PUTBIT/GETBIT. There are seven parameters required for a call on PUTBIT/GETBIT: They are:

- 1. PACKED: the name of the array of packed words
- 2. NBPU: the number of bits per unit for PACKED
- 3. NUNIT: the number of the unit being processed
- 4. IFIRST: the first bit of the field(s) of interest
- 5. LEN: the length of the field(s) of interest
- 6. NUM: the number of fields of length LEN to be packed or unpacked
- 7. IBUF: the array or array element out of which data is to be transferred (PUTBIT) or into which data is to be stored (GETBIT).

With this description and a listing of the program, it is then a matter of carefully perusing the programs to find all PUTBIT/GETBIT references to the modified packed list and making changes as required.

Nonpacked Arrays

The third and last category involves changing the dimensions of an array that is not a packed list. As before, the common block containing the array will have to be replaced wherever it occurs in the program. Additionally, the subroutine that stores data in the modified array must be examined to determine whether or not constraints on the bounds of the array need to be changed.

Table D-1

PREGAME PROCESSOR ROUTINES USING PACKED LISTS, "NAMES," AND "CARDFO"

| | | 1 | | | | | | | 1 | | T | | | Ī | | Ī | | | | |
|-------------------|---------|-------|--------|--------|-------------|--------|--------|--------|--------|-------|-------|-------|--------|--------|--------|--------|--------|--------|-------|--------|
| | TECOMM | | | × | | | X | | | | | | | × | | | | | | |
| | TARGET | × | | | | | | | | | | | × | × | | | × | | | |
| | SHPTYP | | | | × | | х | | | | | | | × | | , | | | | |
| | SHIP | × | | × | × | | × | | | | | | | × | | | | | | × |
| | RADAR | | | | - | | X | | | | | | | × | | | | | | × |
| ¥me | NAMES | | | × | | | X | | | · | | × | X | × | × | | | × | | |
| Common Block Name | MISSL | | | | | | | | | | , | | | X | × | | | × | | |
| Сошшоп | LAUNCH | | | | × | | X | | ٠ | | | | | x | × | | | | | |
| | GUIDCH | | | | × | | X | | | | | × | | X | | | | | | X |
| | CSGECM | X | | | | × | | x | | | | | | X | | | | | | |
| | COMPON | | | X | × | | X | | | | | | × | x | | | | | | |
| | CARDFO | X | X | ×× | > | < × | X | × | × | | X | × | × | X | X | × | × | X | X | x |
| | BOOL | | X | | | | | | | | | | | X | | | | | | |
| Name of | Routine | ACGEN | BOLGEN | CMPGEN | COMINT | CKDAKY | DEFGEN | ECMGEN | ENVGEN | FATAL | FMTNO | GCGEN | GENER8 | INITLZ | LCHGEN | LIST80 | MFPGEN | MSLGEN | NFERR | OPTGEN |

Table D-1 (Concluded)

| No. | Name of | | | | | | Common | Common Block Name | me | | | | | |
|---|---------|------|--------|--------|--------|--------|--------|-------------------|-------|-------|------|--------|--------|--------|
| | Routine | BOOL | CARDFO | COMPON | CSGECM | GUIDCH | LAUNCH | MISSL | NAMES | RADAR | SHIP | SHPTYP | TARGET | TECOMM |
| | PRTBOL | × | × | | | | | | | | | | • | |
| | PRTCMP | | × | × | | | | | × | | | | | |
| | PRTCOM | | × | | | | | | | | × | | | × |
| | PRTCSG | | × | | × | | | | | | | | | |
| | PRTDEF | | × | | | × | × | | × | × | × | | | × |
| | PRTECM | | × | | × | | | | | | | | | |
| | PRTGCG | | × | | | × | | | × | | | | | |
| | PRTLCH | | × | | | | × | | X | | | | | |
| | PRTMSL | | × | | | | | × | × | | | | | |
| | PRTRAD | | × | | | | | | × | • | | | × | |
| X X | PRTRDR | | × | | | | | | × | × | | | | |
| | PRTSHP | | × | × | | × | × | | × | | × | × | | |
| | PRTTGT | | × | | | | | - | × | | | | × | |
| | PURIFY | | × | × | × | × | × | × | | × | × | | × | |
| | RAIDGN | | × | | | | | | | | | | X | |
| | RDRGEN | | × | | | | | | × | × | | | | - |
| | RDTYPE | , | | × | × | × | × | × | × | × | × | | X | |
| | SECGEN | | × | | | | × | | | | × | | | •• |
| | SHPGEN | | X | × | | × | × | | × | × | × | × | | |
| | TGTGEN | | х | | × | | | | X | | | | X | |
| | TYPGEN | | × | | | | | | | | _ | | | |
| X X X X X X X X X X X X X X X X X X X | UNPCOM | | X | X | | | | | | | | | | |
| X X X X X X X X X X X X X X X X X X X | WPNGEN | | X | | | | | | | | | | X | |
| | WRTREP | × | | × | | × | × | | × | × | × | | × | × |
| | WRTYPE | | | × | × | × | × | × | × | × | × | | × | |

Table D-2

NAME FIELD FORMAT REFERENCES
IN PREGAME PROCESSOR ROUTINES

| Name of Routine | For | mat Stat | ement La | bels |
|--------------------|--------------|--------------|--------------|------|
| GENER8 | 2010 | | | |
| LIST80 | 2001 | 2004 | | |
| FMTNO | 1001 | 1004 | | |
| PRTMSL | 2100 | | | , |
| PRTLCH | 2030 | | | |
| PRTRDR | 2130 | | İ | |
| PRTGCG | 2100 | | | |
| PRTCMP | 2040 | | | |
| PRTSHP | 2100 2230 | 2140 2235 | 2180 2340 | 2185 |
| PRTTGT | 2130 | | | |
| PRTDEF | 2130 | | | |
| PRTRAD | 2170 | 2180 | 2500 | |

Table D-3
MAIN SIMULATION PROCESSOR ROUTINES USING PACKED LISTS, "NAMES," AND "REP"

| | | Γ | | \neg | | | | | | Г | | | | | | | | $\overline{}$ | | | | | $\overline{}$ | |
|-------------------|---------|--------|--------|--------|-----------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|------|------|---------------|-------|-------|--------|--------|---------------|--------|
| | TRGDTA | | × | | | | | | | | | × | | | × | | | | | | | × | | × |
| | TECOMM | | | | | | × | | | | | × | | | | | | | | _ | | | | × |
| | TARGET | | | - | | | × | × | | | | | | | | | | | | × | | × | | × |
| | SUMMRY | | | X | | | | | | | | | | | | | | | × | | | × | | × |
| | SHIP | | | | | × | × | | × | | | × | | | | | | | × | × | | | | |
| | REP | | | | x | | | _ | | | | | | | | | | x | | | _ | | | × |
| к Мате | RADAR | | × | × | | | | - | x | | | × | × | × | × | | Х | X | | × | | | | |
| Common Block Name | NAMES | | | | | | | | | | | | | | | | | | | | | | | × |
| Сол | MISSL | | | | | × | | | | | | | | | | | | | | | × | | Х | × |
| | LAUNCH | | | X | | × | _ | _ | | | | | × | × | | | X | | | | | X | | X |
| | GUIDCH | | | Х | | | | | | | | • | × | × | | | X | | | × | | | | |
| | CSGECM | | | , | | | | | | | | | | | | | | | | | | | | |
| | COMPON | × | | | | | | × | | × | × | | | | | × | | | | | | | | |
| | BOOL | | | | | | _ | | | | _ | | | | | | | | | | | | | |
| Name of | Routine | ADJUST | ANTPTN | ASSIGN | CANCEL | COMEGO | COMEIN | COREF | COVERG | DAMFAL | DAMRAT | DETECT | DISCHN | DISLAN | DISRDR | DOWN | DROP | EJECT | ENTER | ERASE | ERLATE | EXPIRE | FLIGHT | GAMINI |

Table D-3 (Continued)

| _ | | | | | | Т | | _ | | | | | | | | | | | | | | |
|-------------------|--------|--------|--------------------|--------|--------|--------|----------------------|-----|--------|--------|-------|--------|--------|------------|--------|---------------------------------------|-------|--------|-------------|-------------|--------|------|
| | TRGDTA | | × | | × | | ×× | | × | | | × > | 4 | | | | | | | ٥ | < | |
| | TECOMM | | | | | | × | | | | | × × | 4 6 | 4 × | | | × | | | > | 4 | - |
| | TARGET | | × | | × | | × | × | × | > | : × | | | | × | | × | | | > | 4 | |
| | SUMMRY | | | | × | × | | | | | | • | | | | | | | | > | . × | |
| | SHIP | | × | | × | | × | | | × | × | ×× | : Þ | ∢ ⋈ | | | × | | | > | : × | |
| | REP | | • | × | | | | × | | × | | | - | | | - | | | | × | : | |
| k Name | RADAR | | | | | × | ×× | | | × | | ×× | 1 | × | | · · · · · · · · · · · · · · · · · · · | × | | • | × | : × | |
| Common Block Name | NAMES | | | | | | | | | | | | | × | × | | × | | | | × | |
| Cor | MISSL | | | | ×× | × | | | | | | | × | | , | | × | | | | | |
| | LAUNCH | | | | × | × | | | | × | | | | × | | | × | | | | × | |
| | GUIDCH | | | | × | × | | | | × | | | | × | | , | × | | × | | × | |
| | CSGECM | | | | | | | | | | | | | | | | × | | | | | |
| | COMPON | × | × × | ₹ | | | | | | | | • | | | | × | × | × | > | < ⋈ | | × |
| | BOOL | × | | | | | | | | | | | | | | | × | - | | | | |
| Name of | | IBOOLE | IMPACT INFA II. | INSERT | INTCPT | LAUNCH | LEAVE LOSE LPE | MSP | NEWPOS | NEXTEV | OUTGO | PASDET | POLYGN | PRTDEF | PRTRAD | RATFAL | RDREP | REDFRD | RELEAS | REPLAY | REPSMR | RPAR |

Table D-3 (Concluded)

| | | | | | | | | | | | | | | - | | - | | | | |
|-------------------|---------|------|--------|--------|--------|--------|-------|-------------|------|--------|--------|--------|-----|----|--------|--------|--------|--------|-------------|--------|
| | TRGDTA | ۶ | < × | : | | | | > | < ; | × | | | | | × | | | | | |
| | TECOMM | | | ٠ | | | | ; | < | | | | | | | | | | Þ | ∢ |
| | TARGET | > | < ≻ | ŧ | | | | | ; | × | × | | | | × | × | × | > | < ; | ∢ |
| | SUMMRY | Þ | < ≻ | 4 | | | | | 1 | × | | | | | | | | | | |
| | SHIP | ×× | < ≻ | 4 | | | | | × | | | | | | | | X | ; | × : | × |
| | REP | | | | | | | | | | | | | | | | | | | |
| к Мате | RADAR | × | < ≻ | ∢ | | | | | × | - | | × | | | | | ; | × | | X |
| Common Block Name | NAMES | | | | • | | | × | | × | | | | | | | | | | × |
| Сош | MISSL | | | | | | | | | | | | | | | | | | | × |
| | LAUNCH | | | | | | | X | | × | | × | | | | | × | × | | × |
| | GUIDCH | | | | | | | × | × | | • | × | | | | | × | × | · | × |
| | CSGECM | | ; | × | | | | | | | | | | | | | | | | × |
| | COMPON | | | | × | × | × | × | | | | • | × | × | | | | | | × |
| | BOOL | | | | | | | | | | | | | | | | | | | × |
| 30 000 | Routine | SCAN | SCAN12 | SCAN34 | SCENAR | SHIPIN | SHPST | TERMIN | TEWA | TGTSMR | TRGPOS | TRNSFR | TTD | ďħ | VANISH | VICTIM | WEPASN | WEPAVL | WPNPRF | WRTREP |

Table D-3A UNIQUE TDHS MODEL ROUTINES AND TDHS MODIFIED MAIN SIMULATION PROCESSOR ROUTINES USING PACKED LISTS, "NAMES," AND "REP."

| | TRGDTA | | | X | | | X | X | | | X | | | X | X | | X | |
|-------------------|-------------|----------------|-------|--------|--------|---------------------------|--------|------------------|--------|-----|------------------|-----------------|--------|------------------|---------------------------|--------|-------------------------|--------|
| | TRACK | X | | X | X | X | X | X | X | X | X | $X \times X$ | X | X | X | XX | X | |
| | TECOMM | | | | | | X | | | | | X | | X | | | | |
| | TARGET | | | | | X | X | X | | | | | | X | X | | XX | |
| | SUMMRY | | | | | X | X | | | | | | | X | | | ×× | |
| | SHIP | | | | | X | | | | | X | X | | X | | X X | XX | |
| | REP | | | | | | X | | | | | X | | X | | | ţ | |
| ock Name | RADAR | XX | X | X | | X | X | | | | X | X | | X | | X = X | XX | |
| Common Block Name | MISSL NAMES | | | | | | X | | | | | X | | | | | | |
| ဝိ | MISS | | | | | | × | | | | | | | | | | | |
| | LAUNCH | | | | | | × | | | | | | | | | | | |
| | сипрсн | • | | | | | | | | | | | | | | | | |
| | CSGECM | | | | | | | | | | | | | | | | X | |
| | CONSOL | × | X | | X | × | X | | | | X | XX | | X | X | X | · | X |
| | COMPON | | | | | | | | | | | | | | | | | |
| | BOOL | | | | | | | | | | | | | | | | | |
| Name of | Routine | ALARM ANTPD | BTERR | CLUSTR | DROPTK | EMERGE ENTER EXTRAP | GAMINI | IFFAIL INZONE | JPRIOR | TSG | NEWTRK NEXTRK | PRTGP PRTTRK | QQUERY | REASET REPLAY | SLEEP SPLTRK SYMUPD | TRACKR | VIDE VIDE12 VIDE34 VIRS | WAKEUP |

Table D-4

NAME FIELD FORMAT REFERENCES
IN MAIN SIMULATION PROCESSOR ROUTINES

| Name of Routine | Form | at State | ement La | abels |
|--------------------|------|----------|----------|-------|
| GAMINI | 1000 | 2000 | 3020 | |
| PRTDEF | 2130 | | | |
| PRTRAD | 2170 | 2210 | | |
| REPSMR | 2030 | 2080 | 2120 | 2160 |
| TERMIN | 4 | 110 | | |
| TGTSMR | 2210 | 2270 | 2320 | |

Appendix E

PREGAME PROCESSOR ERROR MESSAGES

Appendix E

PREGAME PROCESSOR ERROR MESSAGES

The philosophy adopted in the design of the Pregame Processor program has been to continue processing input data unless and until an error occurs which makes it unreasonable to do so. Thus, there are two categories of errors—fatal and nonfatal.

Fatal errors, which are listed in Table E-1, result in a descriptive error message, a listing of the last card read, and termination of the input process. The detection of a fatal error initiates a call on subroutine FATAL. Three parameters required by FATAL are: (1) a calling routine identification number, (2) a local—error type number within the calling routine identifying the particular kind of error, and (3) the identifification number of the format used to read the last card, which, in turn, specifies the print format.

Nonfatal errors, which are listed in Table E-2, result in a descriptive error message including the erroneous value, a listing of the card triggering the message, the setting of a flag which will prohibit the writing of the replication file, and, finally, the initiation of a recovery scheme. The method of recovery—or rather the attempt to continue processing data—will vary from one type of error to another. For one type of error it may be appropriate to assign a maximum value to a variable, for another, a nonzero value, and for others, perhaps the error message is sufficient. The occurrence of a nonfatal error initiates a call on subroutine NFERR, which requires the same three parameters as subroutine FATAL above.

Almost all nonfatal errors involve an attempt to assign an out-of-range value to a variable. A completely different type of error may occur if reference is made to a data set that is either ill defined or not defined at all. For example, if in generating a ship type reference is made to a missile type that was found to be in error or to a missile type that has not been defined, a nonfatal error message will result. Thus a general rule to follow in setting up a data deck is that if reference is made to some particular data set, it should have been previously defined.

Table E-1
FATAL ERROR MESSAGES

| Detecting | Routine | Local Error | |
|-----------|-------------|-------------|---|
| Number | Name | Type Number | Error Message |
| 1 | GENER8 | 1 | The first data card must be a control card (the letter C in Column 1) |
| 2 | LIST80 | 1 | Subroutine LIST80 has been called with a parameter for which there is no print format |
| 3 | CRDARY | 1 | Columns 1-3 must contain the letters Card out of order, missing card, or parameter errordetected by routine CRDARY |
| 4 | FMTNO | 1 | Subroutine FMTNO has been called with a parameter for which there is no read format |
| 5 | TYPGEN | 1 | Illegal entry in Column 2 of a type data header carddetected by routine TYPGEN |
| 6 | MSLGEN | 1 | Number of performance envelope nodes outside of bounds (3,9) |
| | | 2 | Row or column dimension of time of flight array outside of bounds (1,7) |
| | | 3 | Number of vulnerability groups outside of bounds (1,15) |
| 8 | GCGEN | 1 | Number of guidance channel constraint equations outside of bounds (1,8) |
| | | 2 | Number of guidance-channel inflight transitions outside of bounds (0,7) |
| 9 | CSGEN | 1 | Number of rows in cross-section data array outside of bounds (1,7) |
| | | 2 | Number of columns in cross section data array outside of bounds (1,1) |

Table E-1 (Continued)

| Detecting | Routine | Local Error | Error Message |
|-----------|---------|-------------|---|
| Number | Name | Type Number | niioi message |
| 10 | SHPGEN | . 1 | A negative value has been given for the number of radars, guidance- channel groups, channels or launchers |
| 11 | DEFGEN | 1 | A defense card has been read that does not have the letter D in Column 1 |
| | | 2 | A defense card has been read that has neither the letter F nor the letter X in Column 2 |
| 12 | SECGEN | 1 | A sector card has been read that does not have the letter S in Column 1 |
| | | 2 | A sector card has been read that has neither the letter R,L nor X in Column 2 |
| 13 | OPTGEN | 1 | An option card has been read that does not have the letter 0 in Column 1 |
| | | 2 | An option card has been read that has neither the letter R,G nor X in Column 2 |
| 14 | COMGEN | 1 | A communications card has been read that does not have the letter C in Column 1 |
| | | 2 | A communications card has been read that has neither the letter M,S nor X in Column 2 |
| . 15 | RAIDGN | 1 | A raid generator card has been read that does not have the letter R in Column 1 |
| | | 2 | A raid generator header card has been read that has none of the following letters in Column 2A,M,W,X |

Table E-1 (Concluded)

| Detecting | Routine | Local Error | Error Message |
|-----------|---------|-------------|---|
| Number | Name | Type Number | Effor Message |
| 16 | WPNGEN | 1 | The number of legs for a weapon profile must be equal to 1, 3, or 4 |
| 17 | MFPGEN | 1 | The number of legs for a master flight path is outside of bounds (2,16) |
| 18 | ACGEN | 1 | Columns 1-3 of the parasite data card read do not contain the letters RAP |
| 19 | BOLGEN | 1 | Boolean-function card has been read that does not have a letter B in column 1 |
| | | 2 | Boolean-function card has been read that does not have a logic designation |
| 20 | SHPGEN | 1 | Ship-type card has been read that does not have the letters TS in columns 1 and 2 and the letter C, S, or X in column 3 |
| 21 | ENVGEN | 1 | An environmental data card has been read that does not have the letter E in column 1 |
| | | 2 | An environmental data card has been read that does not have the letter N or X in column 2 |
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Table E-2
NONFATAL ERROR MESSAGES

| Detecting Routine | | Local Error | Error Message |
|-------------------|---------------------------------------|-------------|---|
| Number | Name | Type Number | HIOI MOSSAGO |
| 2 | MSLGEN | 1 | The missile type is outside of bounds (1,NMTMAX) |
| | | 2 | Option number for time of flight data outside of bounds (1,3) |
| | | 3 | Option number for missile le- thality data outside of bounds (1,2) |
| 3 | LCHGEN | 1 | Launcher type is outside of bounds (1,NLTMAX) |
| | | 2 | Missile type launched is out- side of bounds (1,NMTMAX) |
| | | 3 | Magazine capacity is outside of bounds (1,63) |
| | | 4 | Number of rails is outside of bounds (1,15) |
| | | 5 | Inter-rail, cycle time or button pushing delay outside of bounds (0,63) |
| | | 6 | Missile type has not been de- fined or is not well defined (errors were detected) |
| 4 | RDRGEN | 1 | Radar type is outside of bounds (1,NRTMAX) |
| | | 2 | Contents of Columns 66-70 = () for radar type exceeds 111 |
| | | 3 | Contents of Columns 71-75 = () for radar type exceeds 11111 |
| 5 | GCGEN | 1 | Guidance channel constraint group type is outside of bounds (1,NGCTMX) |
| | , , , , , , , , , , , , , , , , , , , | 2 | Transition percentages must be non- decreasing |

Table E-2 (Continued)

| Detecting Routine | | Local Error | Error Message |
|-------------------|--------|-------------|---|
| Number | Name | Type Number | HITOI Message |
| 6 | ECMGEN | 1 | ECM loading group index is outside of bounds (1,NECMAX) |
| 7 | CSGEN | 1 | Cross section group index is outside of bounds (1,NTTMAX) |
| 8 | SHPGEN | 1 - | Ship type is outside of bounds (1,NSTMAX) |
| | | 2 | Total number of guidance channelsexceeds 63 |
| | · | 3 | Total number of missile launchersexceeds 15 |
| | | 4. | At least one radar type has not been defined or is not well defined (errors were detected) |
| | | 5 | Tracking radar type has not been defined or is not well defined (errors were detected) |
| | | 6 | Guidance-channel constraint-group type has not been defined or is not well defined (errors were detected) |
| | | 7 | Missile type has not been de- fined or is not well defined (errors were detected) |
| | | 8 | Total number of launchers for all G.C. groups not equal to number of launchers specified on card type TS |
| | | 9 | Total number of guidance channels for all G.C. groups not equal to number of channels specified on card type TS |
| | | 10 | Number of launcher types for this group is outside of bounds (1,3) |

Table E-2 (Continued)

| Detecting Routine | | Local Error | Error Message |
|-------------------|--------|-------------|---|
| Number | Name | Type Number | |
| 8 | SHPGEN | 11 | Number of radars exceeds 7 |
| | | 12 | Number of guidance channel groups exceeds 7 |
| | | 13 | Number of component groups may not exceed 10 |
| | | 14 | A local radar assignment may not exceed the number of scanning radars |
| 9 | TGTGEN | 1 | Target type is outside of bounds (1,NTTMAX) |
| | | 2 | Vulnerability or cross-section group outside of bounds (1,NTTMAX) |
| | | 3 | Cross-section group has not been defined or is not well defined (errors were detected) |
| 10 | DEFGEN | 1 | Defense unit number outside of bounds (1,ISMAX) |
| | | 2 | Ship type has not been defined or is not well defined (errors were detected) |
| | | 3 | Total number of radars for all defensive units has exceeded limit IRMAX |
| | | 4 | Total number of guidance channel groups for all defensive units has exceeded limit IGCGMX |
| | | 5 | Total number of guidance channels for all defensive units has exceeded limit IGCMAX |
| | | 6 | Total number of launchers for all defensive units has exceeded limit ILMAX |
| 11 | SECGEN | 1 | Ship number not within task- force limits |
| | | 2 | Ship number is not in the task force |

Table E-2 (Continued)

| Detecting Routine | | Local Error | |
|-------------------|--------|-------------|--|
| Number | Name | Type Number | Error Message |
| 12 | OPTGEN | 1 | Ship numberis not within task- force limits |
| | | 2 | Ship numberis not in the task force |
| 13 | COMGEN | 1 | Ship numberis not within task- force limits |
| | | 2 | Ship numberis not in the task force |
| | | 3 | Communications indicator is outside of bounds (0,1) |
| | | 4 | A value has been specified for MODX on the type CX card that is outside of bounds (0,3) |
| 14 | WPNGEN | 1 | Weapon profile numberis outside of bounds (1,JWPMAX) |
| | | 2 | THETA1 or THETA2 not in interval (0,89) |
| | | 3 | Dimension of paths array and value of LPATH must be increased for storing flight path data |
| 15 | MFPGEN | 1 | A negative or zero speed has been detected |
| | | 2 | Dimension of paths array and value of LPATH must be increased for storing flight pat h data |
| 16 | ACGEN | 1 | The nuber of targets generated has exceeded JTMAX |
| | | 2 | Target typeoutside of bounds (1,NTTMAX) |
| | | 3 | Target typehas not been defined or is not well defined (errors were detected) |
| | | 4 | ECM loading group has not been defined or is not well defined (errors were detected) |
| | | 5 | Weapon profileis outside of bounds (1,JWPMAX) |

Table E-2 (Concluded)

| Detecting | Routine | Local Error | |
|-----------|----------|-------------|---|
| Number | Name | Type Number | Error Message |
| 16 | ACGEN | 6 | Weapon profilehas not been defined |
| | | 7 | Ship under attackis outside of bounds (1,ISMAX) |
| | | 8 | Ship under attackhas not been defined |
| | · | 9 | Launch node is outside of bounds (1,NODES-1) |
| | | 10 | Maximum launch time must be less than arrival time at last node |
| | | 11 | Dimension of paths array and value of LPATH must be increased for storing flight path data |
| | | 12 | A failure probability is outside of the range $(0,1)$ |
| 17 | SHPGEN | 1 | Inconsistency between radars and component types referring to radars on ship type |
| | | 2 | Inconsistency between guidance channels and component types referring to guidance channels on ship type |
| | | 3 | Inconsistency between launchers and component types referring to launchers on ship type |
| | | 4 | No ship geometry for ship type |
| | | 5 | Ship typehas not been defined or is not well defined (errors were detected) |
| 18 | BOLGEN | 1 | A Boolean function with a previously defined number has been read and ignored. |
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| | <u> </u> | <u> </u> | <u> </u> |

Appendix F

GUIDANCE-CHANNEL CONSTRAINT-GROUP CONCEPT

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Appendix F

GUIDANCE-CHANNEL CONSTRAINT-GROUP CONCEPT

Simulation of SAM weapon systems in this model employs the concept of guidance-channel constraint groups (GCCG). Generation of a GCCG type is accomplished with the TG, TGP, TGC, and TGA input cards to the PGP as described in Appendix A. The weapons configuration of a particular ship type is then defined in terms of the applicable GCCG types with one or more TSG input cards. Finally, as individual defense units are defined through the use of DF input cards to the PGP, guidance channel constraint groups are produced, each having a contiguous set of associated guidance-channel numbers.

The guidance channels associated with a particular missile launcher (or group of launchers, as appropriate) are termed a guidance-channel group. For each such guidance channel group there exists a set of constraint information which has the effect of limiting the number of simultaneous engagements that it may conduct. Several parameters are used to define the constraint expressions for a guidance-channel group. These are delineated here with examples in terms of familiar system concepts.

First is the number of inflight guidance (data rate) transitions, NTRANS, made by the missile. For a semiactive, homing-all-the-way system, NTRANS would be 0; for a command-midcourse, active terminal seeker missile it would be 1. Up to seven inflight data-rate transitions are allowed with the present model dimensioning. It is felt that this is sufficient to accommodate any foreseeable guidance logic schemes as well as all of the presently implemented ones.

In order to reduce the simulation algorithms to manageable proportions, it has been postulated that the transition events can be stated in terms of percentages of the total missile time-of-flight. That is, midcourse to terminal homing transition may be specified as taking place at a point when 90% of the predicted flight time has elapsed. Conversely, fixed or constant time values may not be used for the specification of the transition points (e.g., 10 seconds prior to predicted intercept).

The "state" of a missile assignment is defined to be equal to the number of the next transition through which the missile will pass. Thus, prior to launch and until the first transition (if there is one) a missile is in state 1; from intercept time (and perhaps earlier) to release time the missile is in state NTRANS+1. A column vector, P, of dimension NTRANS+1 specifies the points in time at which transitions are made from one state to the next, expressed in percent of total flight time. The components of this vector must be nondecreasing; that is $\mathbf{p}_{\mathbf{i}+1} \geq \mathbf{p}_{\mathbf{i}}$ where

$$P = \begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ p_i \\ \vdots \\ p_{NTRANS+1} \end{pmatrix}$$

By application of the vector P to all missile assignments currently being serviced by the guidance channel group under consideration, a time-ordered transition list may be constructed. From this list a time-varying column vector S(t) may be obtained where the components $s_i(t)$ represent the total number of missile assignments in state i at time t. At the earliest assignment time of a currently held engagement $s_1(t) = 1$, and all other components of S(t) would be 0. Similarly, at the latest release time of

a currently held engagement $s_{NTRANS+1}(t) = 1$, and all other components of S(t) would be 0. In between these two times the numerical values of the $s_i(t)$ components may be of any magnitude consistent with the constraint expressions explained below.

Briefly the guidance-channel-constraint expression may be stated in matrix form as:

$A S(t) \leq NC$ for any value of t

where

A = an NROW by NTRANS+1 array of coefficients

S(t) = the NTRANS+1 by 1 column vector of assignments in each state at time t

C = an NROW by 1 column vector of constraint values

NROW = the number of constraint equations associated with the guidance channel constraint group (i.e., the row dimension of A and C).

In evaluating the constraint expression above, it is assumed that all currently held assignments have satisfied the constraint equation prior to the current time, and future assignment decisions are made on the basis of the continued availability of those guidance channels currently active.

A new missile assignment will be made only if the constraint expression above would remain satisfied during the entire history of the proposed assignment (i.e., from assign time to release time). As battle damage is inflicted on guidance channels the constraint expressions become more restrictive and may force premature termination of one or more currently held assignments.

By way of example, consider the dual-simplex guidance system wherein a single missile launcher has two fully dedicated tracking (guidance/illuminator) radars providing semiactive, homing-all-the-way guidance to at most two concurrent independent missile engagements. The corresponding guidance-channel constraint group parameters would be:

NTRANS = 0

NROW = 1

N = 2

P = 100

A = 1

C = 1

Since there are no inflight transitions associated with this type of guidance system, the matrix multiplication reduces to the scalar inequality:

$$s_1(t) \leq 2$$

where \mathbf{s}_1 (t) is the number of assignments serviced by the two available guidance channels at any time t. If battle attrition should disable one of the tracking radars, then the right-hand term in the inequality above would become 1.

As a second example, consider a hypothetical missile system having a midcourse and a terminal-homing guidance phase with the transition occurring when one-fifth of the expected flight time remains. Let M denote the number of assignments in midcourse phase and T denote the number in terminal phase. Further, stipulate that the N guidance channels are to obey the inequalities:

$$M + T \leq 2N$$

$$2M + 11T < 5N$$

The constraint parameters for this system would be:

NTRANS = 1
NROW = 2
N = 20
P =
$$\binom{80}{100}$$

A = $\binom{1}{2}$ 11
C = $\binom{2}{5}$

The resulting constraint equation would be:

$$\begin{pmatrix} 2 & 1 \\ 2 & 11 \end{pmatrix} \quad \begin{pmatrix} s_1(t) \\ s_2(t) \end{pmatrix} \leq 20 \begin{pmatrix} 2 \\ 5 \end{pmatrix}$$

where the values of $s_1(t)$ and $s_2(t)$ correspond to the number of assignments in midcourse or terminal guidance respectively at any time t.

It may be observed that the value of NROW need never exceed NTRANS+1 since this would correspond to a redundant inequality expression.

Appendix G

GAME COMPONENT PARAMETERIZATION

Appendix G

GAME COMPONENT PARAMETERIZATION

Damage-assessment, reliability, repair, and system dependencies within the model are based on the representation of each ship in the task force by a collection of elementary costing units, called elements or components. Examples of elements include a propeller shaft, a fire-control computer, a launcher rail, a radar antenna, a radar system, and an entire ship. In these examples the components are not necessarily mutually exclusive. In fact many shipboard systems are represented conveniently by elements that are not mutually exclusive.

As the play of a game progresses, an element might become inoperable for at least one of three reasons: the element might have been damaged by the detonation of an enemy missile that has penetrated the fleet's defenses, the element might have failed randomly, or another element on which the operation of this element depends might have become inoperable. If an element becomes inoperable, any other elements whose operation depends on that element will remain inoperable at least as long as it does. Thus during the play of a game elements become operable and inoperable as elements fail or are damaged and repairs occur. Concurrently the cost to the fleet of these events is computed, and the defensive capability of the fleet is reflected through the operability states of sets of elements representing ships in the fleet.

In terms of the model an element is an abstraction described by a number of parameters detailing its location, reliability, and vulnerability as well as its functional dependency upon other elements. For example, associated with each component is a replacement cost, a position expressed in local ship coordinates, and an on/off state. The replacement cost depends on the component type*; the position of the component depends on the ship type to which the component has been assigned**, and the on/off state depends on the particular ship on which the component is located. This example illustrates three levels at which parameters describing components are stored (component type, ship type, and ship).

Associated with each component in the game are ten different but redundant pointers. In effect, six of these pointers as listed in Table G1 are assigned to each component by the user, but the remaining four as listed in Table G1 are assigned by the PGP. The component number, which is assigned by the PGP, is the only label which is unique to each component in the game. Therefore, given a component number, all the other corresponding pointers can be derived by employing various relations. These relations will be detailed in the following illustration. All cited arrays and packed list are in common block COMPON.

^{*}See Appendix A, Card Types TP, TPO

^{**}See Appendix A, Card Type TSC

Table G1-Component Identifiers Assigned by User

| Identifier | Description |
|---------------------------------|--|
| Component-type number | Refers to the unit in packed list ICTPAR in which component-type parameters are stored |
| Ship-type number | Refers to the ship type on which the component is located |
| Ship number | Refers to the ship on which the component is located |
| Component identification number | Identifies the Boolean function that describes the dependency of this component on the other components |
| System code number | Indicates whether this component is a radar, guidance-channel, launcher, other component type |
| System type number | Yields type of radar, guidance channel, or launcher in case the component is a radar, guidance channel, or launcher as indicated by System Code |
| Component Number | A unique label for each component in a game. It refers to units in packed lists ICOMPO, NCCCDT, NONOFF, NTRHO, and NUDOOF. |
| Ship Type Index | This index is in a one-to-one correspond- ence with the user-assigned ship-type number. It refers to entries in arrays NCOMP and NNSPGO |
| Ship Index | This index is in a one-to-one correspond- ence with the user-assigned Ship Number. It refers to entries in array NCOMPS. |
| Ship Type Component Number | A unique label for each component within a ship type. It refers to units in packed lists NBOVAR and NSTCOM |

Denote a component number by NSCI, and let the corresponding ship type component number, ship index, and ship type index be NSTCI, NSN, and NSTN respectively. Components for ship index I are indexed from NCOMPS(I) through (NCOMPS(I+1)-1), and if J is the corresponding ship type index, then

J = NSNST(I).

So NSN, the ship index corresponding to NSCI, is that value for which NCOMPS(NSN) & NSCI < NCOMPS(NSN+1),

and NSTN, the ship type index corresponding to NSCI, is NSTN = NSNST(NSN).

Ship NSN has exactly the same number of components as ship type NSTN has ship-type components, and the ship components and ship-type components are in the same order. Since the ship-type components on ship-type NSTN are indexed from NCOMP(NSTN) through NCOMP(NSTN+1)-1, it follows that

NSTCI = NCOMP(NSTN) + NSCI - NCOMPS(NSN).

Given NSCI, the corresponding values of NSN, NSTN, and NSTCI are computed in subroutine BOOK.

Finally the user-assigned ship number and ship-type number are given by NUN(NSN) and NSTPN(NSTN) respectively, and the component-type number, identification number, system code, and system type are found in unit NSTCI of packed list NSTCOM.

Appendix H

SAMPLE PGP INPUT DECK AND SUMMARY LISTINGS

Appendix H

SAMPLE PGP INPUT DECKS AND SUMMARY LISTINGS

To illustrate the use of the Pregame Processor, two sample input card decks have been prepared one for the parent model and one for the TDHS version. The resulting printer listings are reproduced here. No particular importance should be given to the exact numerical values used in these sample decks, since many values are ficticious so as to keep the material unclassified. Similarly, the ships and associated ship-type configurations as defined in the TYPGEN and DEFGEN inputs, respectively, as well as the raid structure and attack tactics described in the RAIDGN inputs have no particular strategic significance.

Each of the 48 card types has been used at least once in the sample decks, and most (but not all) of the data input options have been exercised. The interdependence of the data sets can be observed both by the ordering of cards within the card decks and by the numerical crosslinking (or indexing references) within the data specifications.

Floating-point variables are typically shown in the listings with three figures to the right of the decimal point. This of course does not restrict the range of values such parameters may assume, since any numerical value capable of being represented* in ten card columns is acceptable.

^{*}All floating point values are read from cards with an F10.3 format; however a decimal point on a data card will override the format.

Parent Model Sample Pregame Processor Input Deck

| С | nS | AMPLE TE | ST | CASE | | 0 | 0 | 1 | ł | 1 | 0 | Õ | 0 | 0 | 0 |
|-----|----|------------|-------------|------------|-----------------|------------|------|-------|-----------|------------|-------|-----|-----|--------|-----|
| TG | ī | DUAL SI | | | | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| • - | - | | | | | 0 | | ŏ | ō | ŏ | ŏ | 7 | • | Ŏ | Ŏ |
| TGP | 2 | 100 | 0 | 0 | 0 | • | 0 | • | - | - | - | 0 | 0 | 7 | |
| TGC | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ò | 0 |
| TGA | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ų | 0 |
| TM | 1 | FOCK TAL | _CS | | | 1 | -5 | 3 | 2 | 3 | 2 | 3 . | 100 | 0 | 0 |
| TMP | ž | 5.00 | | 338 | •400 | 200 | .000 | | 5-000 | 300 | 000 | ï5. | 900 | 335.0 | 00 |
| TMP | 3 | 100.00 | | | •000 | | .000 | | 000 | | 000 | -0- | 000 | =0 • 0 | 80 |
| | _ | | _ | | | | | | 710 | 400 | | _ | 480 | ₩0.0 | |
| TMT | 4 | 0.00 | | | •000 | | •000 | 47 | | | | | • | ~~~~ | |
| TML | 5 | | +7 | 12 | 70 | 4 | 3 | • • | 25 | 10 | _0 | 0 | 0 | Ŏ | 0 |
| TL | 1 | MARK 12 | | | | 7 | 1 | 45 | 2 | 2 | 35 | 2 | 0 | Ų | 0 |
| TR | 1 | | SPG | | | 7 | 4 | 20 | 10 | | 000 | 0 | Q | 0 | . 0 |
| TRI | 2 | 15 | 0 | 18 | 18 | 32 | 3 | 2 | 3 | 5 | 10 | 1 | 1 | 101110 | 10 |
| TRF | 3 | 12.00 | ÒO | | •000 | 2 | .700 | 1 | 2-500 | 2. | ,225 | 20. | 000 | 0.1 | .00 |
| TRF | 4 | 0.78 | | | •000 | | .000 | | 0-000 | | 000 | | 000 | 70 • 0 | 00 |
| , | • | | | | • 000 | - | | | | | | | | 0 | 0 |
| TR_ | 1 | MOCK AN | | | | <u>_1</u> | 1 | 0 | 9 | 16 | 1536 | Ō | Ō | ĭ | ľ |
| TRI | 2 | • | +0 | 18 | 16 | 25 | _ • | 3 | 5 | 3 0 | 10 | 1_ | 1 | - | - |
| TRF | 3 | -90.00 | 00 | 75 | •000 | 2 | .500 | (| 6.000 | 0, | 300 | 25. | 900 | 0.1 | 90 |
| TRF | • | 0.17 | | -0 | • 000 | ~ 0 | .000 | - | 000 | =0. | 000 | -0. | 900 | -0.0 | 00 |
| ΤP | Õ | LAUNCHE | | • | - • • • | | 1000 | 200 | 20 | 10 | 30 | 3 | 30 | 3 30 | 90 |
| | - | _ | _ | ٥ | ^ | Ō | 1040 | -0 | - ŏ | Õ | ő | 0 | Õ | ō | 0 |
| TPC | 0 | 10 | 0 | U . | . 0 | - | 100 | • | - | - | _ | V | | • | 00 |
| TP | 0 | SCAN RAI | | _ | _ | 5 | 100 | 1000 | 70 | 500 | 40 | • | 40 | | |
| TPC | 0 | 4 | . 0 | 0_ | . 0 | 0 | . 0 | 0 | _0 | 0 | 0 | 0 | _0 | 0 | 0 |
| TP | 0 | GUIDANCE | E CH | IANNE | Ļ | 3 | 200 | 1000 | 50 | 20 | 20 | 2 | 20 | 2 20 | 00 |
| TPC | 0 | ` 4 | 0 | 0 | . 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TP | ō | POWER SI | JPPL | Υ . | | 2 | 1000 | 100 | 10 | 10 | 10 | 1 | 10 | 1 10 | 00 |
| TPC | 0 | 15 | 0 | 0 | 0 | Ō | 0 | 0 | Ö | 0 | 0 | ō | 0 | 0 | 0 |
| , - | - | SHIP | v | v | v | ĭ | • | 10000 | ŏ | ŏ | ŏ | ŏ | ŏ | Ŏ | Õ |
| TP | 0 | | • | | | _ | | 0000 | ŏ | ŏ | Ŏ | - | Ŏ | ŏ | ŏ |
| TPC | 0 | 0 | _0 | 0 | 0 | 0 | 0 | _ | - | - | - | . 0 | - | • | - |
| TS | 1 | TEST SH | IP T | YPE | | 2 | 1 | 1 | 2 | 1 | 0 | Ó | 0 | 0 | 0 |
| TSR | S | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TSG | 3 | 7 | 2 | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TSC | 0 | 14 | 4 | 10 | 10 | 20 | 1 | . 0 | 3 | 7 | 0 | 0 | 0 | .0 | 0 |
| TSC | Õ | 1 5 | :5 | Ö | Ō | 50 | Ĭ | 0 | t | 1 | 0 | Ô | Ō | 0 | 0 |
| TSC | Ö | • 3 | 3 | 20 | 20 | 25 | i | Ŏ | Ž | Ž | Ŏ | Ŏ | ŏ | Ŏ | Ö |
| TSC | 0 | 13 | 3 | 50 | - 20 | 25 | i | ŏ | 2 | 2 | ŏ | ő | ŏ | ŏ | ŏ |
| | _ | _ | | | | | | • | | | - | - | - | - | - |
| TSC | 0 | 12 | 2 | Ō | 0 | -10 | 0 | _ 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TSC | 0 | 11 | _ 1 | 0 | 0 | _ 0 | _1 | 500 | - | 0 | 0 | 0 | . 0 | 0 | 0 |
| TSH | 0 | 25 | 25 | 150 | 100 | 35 | 25 | 30 | 30 | 0 | 0 | 0 | 0 | .0 | 0 |
| TSS | 0 | -75 | 0 | 30 | 75 | 25 | 20 | 0 | 0 | 0 | 0 | 0 | Q | 0 | 0 |
| TSX | 0 | 0 | . 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ó | 0 | 0 |
| TC | ň | · | - | • | - | Ž | Ĩ | 5 | 1 | 1 | Ô | ň | Ô | 0 | 0 |
| TCC | į | 2.0 | 0.0 | 1 | .800 | | .300 | _ | 2-100 | ٠, | .500 | | 900 | -0.0 | 100 |
| TT | | MOCK BE | | . • | 4 000 | 5 | 3 | 2 | | 0 | • 500 | - | 0 | 0 . | Ô |
| | 1 | | AL | | | | _ | | | - | - | 300 | _ | 25 | 15 |
| TT | 1 | MISSILE | | | | 9 | 2 | 2 | | 15 | 0 | 200 | 10 | | |
| ŢΧ | 0 | | | | | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| BF | 0 | | ND | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ō | 0 |
| BF | 0 | 13 A | ND | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8F | 0 | 14 A | ND | 12 | 0 | 0 | Ō | 0 | 0 | 0 | 0 | 0 | 0 | . 0 | 0 |
| BF | Ö | • | NC | 12 | Ŏ | Ŏ | Ŏ | Ŏ | Ŏ | Ō | Ŏ | Õ | Ö | Ò | 0 |
| BF | 0 | _ | OF | • 3 | 13 | 14 | 15 | ŏ | | ŏ | ŏ | Ô | Ŏ | Ö | Ŏ |
| | - | | 4 11 | _ | - | 17 | | ŏ | ŏ | Ŏ | Ö | | Ö | ň | Ö |
| BX | 0 | 0 | | 0 | 0 | - | 0 | • | . <u></u> | • | - | 0 | - | · · | • |
| DF | 0 | TEST SH | | ONE | | 1 | .5 | 1 | | | •000 | | 900 | - | 000 |
| DF | 0 | TEST SH | IP 1 | TWO | | 2 | 2 | 1 | 35 | 2 | •500 | 1 | 500 | 0 • (| 000 |

| DX | 0 | | | | * | 0 | C | 0 | 0 | 2.000 | 1.000 | -0.000 |
|------------|---|------|-----|-------|-------|--------------|--------------|----------|-----|---------|-----------|--------|
| SX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 0 | ò o | 0 0 |
| ΟX | 0 | -0 (| 0 (| 0 0 0 | 0 0 0 | 0 0 | 0 0 | 0 0 6 | 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 |
| СX | 0 | -0 (| 0 (| 0 0 0 | 0 0 0 | 0 0 0 | 6 8 0 | 0 0 | 0 0 | 00000 | | 0 0 0 |
| ĒΝ | Õ | 20 | 000 | 5000 | .000 | 0 | 960 | -0. | 000 | -0.000 | -0.000 | -0.000 |
| ĒΧ | Õ | -0. | 000 | -0 | •000 | - 0 | .000 | -0 | 000 | -0.000 | -0.000 | -0.000 |
| RW | ň | 1 | | 2500 | 0 | o T | 0 | 0 | 0 | -0.000 | -0.000 | -0.000 |
| RW | ň | ż | | 2500 | | | ŏ | 30 | 30 | 50.000 | -0.000 | -0.000 |
| RM | • | ~ | ٥ | 3 | | | 0 | 0 | 7 | | | |
| | ņ | , , | | _ | 0 | _ 0 = 0 0 | 200 | <u> </u> | 0 | | -1000.000 | 50.000 |
| RMF | Ť | | 000 | | •000 | -500 | | | 000 | 800.000 | 0.000 | 0.000 |
| RMF | 2 | 3 | 000 | 600 | •000 | - 0 | .000 | -0 | 000 | -0.000 | -0.000 | -0.000 |
| RA. | 0 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0.000 | 0.900 | 0.000 |
| RAP | 0 | 9 | 0 | 1 | 1 | 1 | 10 | 10 | 0 | -0.000 | -0.900 | -0.000 |
| RAP | 0 | 9 | 0 | 1 | 1 | 2 | 20 | 20 | ł | 10.000 | 5.000 | 0.000 |
| RAP | 0 | 9 | 0 | ĩ | 1 | 1 | 30 | 30 | 0 | -0.000 | -0.000 | -0.000 |
| RA | Ŏ | 5 | 0 | 4 | O | Ō | ō | Ō | Ö | 2.000 | 30.000 | 20.000 |
| RAP | Ó | 9 | Ō | 2 | i | ì | 10 | Ò | ì | 0.000 | 0.000 | 0.090 |
| RAP | ŏ | 9 | ō | 2 | ī | ĭ | 50 | 10 | ž | 0.000 | 0.600 | 0.000 |
| RAP | ň | 9 | ŏ | 2 | i | ż | 10 | Ŏ | i | 0.000 | 0.000 | 0.000 |
| RAP | ň | á | ň | 5 | • | 5 | 50 | 10 | i | 0.000 | 0.000 | 0.000 |
| RX | | á | | _ | • | _ | 20 | • 0 | • | | • • • • • | |
| ™ ^ | U | U | u | U | U | U | - 0 | U | u | -0.000 | -0-800 | -0.000 |

TYPE GENERATOR INPUTS

MISSILE TYPE NUMBER 1. MOCK TALCS

| PERFORMANCE ENVELOPE | ENVELOPE | RMIN # | 2.000 | RMAX = 338.400 | 338.400 | NUMBER OF NODES = 5 | 0 | NODES | II | |
|----------------------|-------------|-------------------|----------------------------------|------------------|----------|---------------------|------|---------|----|--|
| NODE | FANGE | ALTITUDE 0.000 | w. | | | | | | | |
| • ~ | 200.000 | 000 • 9 | | | | | | | | |
| m | 300.000 | 15.000 | _ | | | | | | | |
| 4 tù | 335.000 | 100.000 | | | | | | | | |
| TIME OF FLIGHT | HT OPTION | ю | NUMBER OF ROWS # 2 | ROWS = 2 | | NUMBER OF COLUMNS | NWO. | en H | | |
| T.0.F | T.O.F. DATA | 0.000 | 200.080 | 400.000 2.480 | 0.000 | | | | | |
| LETHALITY | OPTION 2 | | NUMBER OF VULNERABILITY GROUPS = | RABILITY | GROUPS . | 60 | | | | |
| GROUP | PX 44 | SIGMA 12 | | | | | | | | |
| u (| - t |) : | | | | | | | | |

TYPE GENERATOR INPUTS

PAGE 2

| | BUTTON PUSHING TIME DELAY |
|----------------|-------------------------------|
| | BUTTC |
| | CYCLE TIME 35 |
| | INTER RAIL TIME DELAY 2 |
| | NUMBER OF RAILS |
| | MAGAZINE CAPACITY 45 |
| | MISSILE TYPE Launched 1 |
| S | NAME NAME 12 |
| LAUNCHER TYPES | NUMBER 7 |

COST OF UNIT MISSILE IN DOLLARS = 100000

| | | | NO. OF PULSES INTEGRATED 10 | | ENGTH O.1 O.1 |
|-------------|---------------|---------------------------------|---|--|---|
| | ACOPE TMIT | 1000 | RCVR. ADISE NO. FIGURE IN | | PULSE LENGTH TRANS. RCVD. 25.0 0.1 |
| | SCAN | | | | PP POSA 00 2000 0000 0000 |
| | KILL EVAL. | | E LOSSES TRANS, RCVR. | RESOLUTION APPLICABILITY 11010 | HIDTH RTICAL 6.0 2.5 |
| | 161. ACG. | | N SIDELOGE LEVEL 25 | BILITY | RCVR. 3DB BEAMWIDTH HORIZON'AL VERTICAL 2.5 6.0 2.7 2.5 |
| | RADAR FREG. | 2 2 2 3 3 4 4 | ANTENNIS GAIN TRANS. RCVR. 18 16 18 18 | • | NO. |
| | A S | MOCK AN/SPS-29 BR | RCVR, IF NOISE BANDWIDTH T 40 | ANTENNA PATTERN FCT. INDEX Horizontal Vertical 1 | VERT. ANGLE COVERAGE COWER BCUND UPPER BOUND -90.0 12.0 90.0 |
| | NAME | MOCK MOCK MA | ENGTH BOOTH | ANTENNA HORIZ | VERT. |
| RADAR TYPES | NUMBER | | NUMBER | NUMBER 1 | NUMBER 1 |

FALSE ALARM PROB. FACTOR 10

SPEED RES. (KFT/SEC) 0.123

DERIVED RADAR PARAMETERS

| RANGE RES. | 640.0 |
|-------------------------|------------|
| NORMALIZED THRESHOLD | 94.179629 |
| SUBPULSES PER PULSE | -d-M |
| NUMBER | ~ ^ |

TYPE GENERATOR INPUTS

PAGE 4

| DUAL SIMPLEX | |
|--|---|
| | |
| ò | , H |
| E NUMBER | S GROUP # |
| Ϋ́ | THI THI |
| GROUP | ELS IN TA RATE |
| GUIDANCE CHANNEL CONSTRAINT GROUP TYPE NUMBER 2. | TOTAL MUMBER OF CHANNELS IN THIS GROUP #: 2 NUMBER OF INFLIGHT DATA RATE TRANSITIONS # 0 NUMBER OF CONSTRAINT EQUATIONS # 1 |
| REL | 9.99 |
| ¥ | ֓֞֓֓֟֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓ |
| GUIDANCE C | TOTA NUMB NUMB |

300

M

*

| | TIME TO DIE REPAIR RATE PEAK MEAN STD:0EV. OVERPRESSURE (SECONDS) (DOLLAHS/HR.) (LBS./SQ.IN.) 0 0 0 0 0 10 1 1000 10 15 0 2 2000 20 4 10 3 3000 30 10 40 4 4000 40 4 | PAGE 6 |
|-----------------|--|-----------------------|
| | EXP. REPARR E(R) OELAY TIME E(R) (MINUTES) 0.000 0.010 2 0.020 3 0.040 4 | SİNANI |
| | REPLACEMENT VULNERABILITY (OCLLARS) E(R) K (OCLLARS) 0.000 0.000 100000 100000 0.050 0.020 0.020 100000 0.020 0.010 100000 0.020 0.010 100000 0.070 0.500 | TYPE GENERATOR INPUTS |
| COMPONENT TYRES | NUMBER MAME BET. FAILS I SHIP OOUES 2 POWER SUPPLY 250.00 4 LAUNCHER 50.00 5 SCAN RADAR 250.00 | CROSS SECTION GROUPS |

MODEL NUMBER 1 1.500 NUMBER OF COLUMNS # 1 2.100 2+300 OPTION 1 NUMBER OF ROWS = 5 1.800 2.000 ARRAY TRANSPOSE GROUP NUMBER 2

| | | |) | | | | | | | |
|--|------------------|--------------|---|---------------------|------|--|---------------------|------------|------------|---------------------------|
| KEEL | KEEL DEPTH 25 | HULL HULL | HULL PARAMETERS HULL MEIGHT Y(1) 25 150 | TERS Y(1) 150 | Y(2) | Y(2) Y(3) Y(4) 100 35 25 | ₹(4) 25 | 9(5) Y(6) | ¥(6) 30 | |
| | | RECT | RECTANGULAR SOLIDS | SOLID | " | | | | | |
| 200 X 1 | 51,110 Y | N 30 | LENGTH WIDTH HEIGHT 75 25 20 | WIDTH 25 | HE16 | Ė | | | | |
| NUMBER OF SCANNING RADARS # 1 | SEANIN | G RADA | RS = 1 | | | | | | | |
| SURVEILLANGE RADAR TYPE NUMBER NAME | ADAR TY | PE | POSITION | POSITION X Y Z | # F | EXTERIOR(1)/ INTERIOR(0) INDICATOR |) () () () | ∢ ∺ | SSOCIAT | ASSOCIATED COMPONIED TYPE |
| Σ | NSPS- | 6 | 0 | 0 20 | | | | - | 15 | 5 SC |

| SCENARIO COST INDEX 0 | | SCENARIO COST GUIDANCE CHANNEL GROUP INDEX NO. TYPE 0 1 2 | | MISSILE TYPE COST ASSOCIATED LAUNCHED INDEX G.C. GROUP NO. NAME 0 1 1 MOCK TA |
|---|--|---|-------------------------------|---|
| ASSOCIATED COMPONENT ID TYPE NAME 15 5 SCAN RADAR | | ASSOCIATED COMPONENT ID TYPE NAME 3 GUIDANCE CHANNEL 13 GUIDANCE CHANNEL | | ASSOCIATED COMPONENT ID TYPE NAME 14 4 LAUNCHER |
| EXTERIOR(1)/ INTERIOR(0) INDICATOR | | EXTERIOR(1)/ INTERIOR(0) INDICATOR 1 | | EXTERIOR(1)/ INTERIOR(0) INDICATOR |
| POSITION X Y Z 0 0 50 | NNELS # 2 | POSITION X Y Z ZO 20 25 ZO =20 25 | CHERS = 1 | POSITION X Y Z 10 10 20 |
| SURVEILLANGE RADAR TYPE Number 1 mbgk an/sps-29 | NUMBER OF GUIDANCE CHANNELS * NUMBER OF GUIDANCE CHANNEL GRO | TRACKING RADAR TYPE NUMBER NAME 7 MOCK AN/SPG-49 7 MOCK AN/SPG-49 | NUMBER OF MISSILE LAUNCHERS . | LAUNCHER TYPE NUMBER NAME 7 MARK 12 |

| | SCENARIO | COST | INDEX | 0 | 116 |
|----------------------------|--------------|-------------|-----------|--------------|------|
| | EXTERIOR(1)/ | INTERIOR(0) | INDICATOR | 0 | |
| | | POSITION | Z A X | 0 0 -10 | 0 0 |
| ADDITIONAL SHIP COMPCNENIS | | | NAME | POWER SUPPLY | SHIP |
| AL SHIP | | | TYPE | ~ | - |
| ADDITION | | | 10 | 12 | 11 |
| | | | | | |

| _ 00 |
|-------------------------------------|
| FUZE DELAY (FEET) 0 25 |
| VELOCITY STD. DEV. |
| EQUIV. TNT |
| GUIDANCE DEP. 0 |
| DEPA REP/ GCEP OPTION 15 |
| DEPA CEP 15 |
| CBOSS SECT. GROUP 2 2 2 |
| VULNER. GROUP 3 |
| NAME MOCK BEAR MISSILE |
| NUMBER 5 |

PROB . DUD 0 • 00 0 • 15

TYPE GENERATOR INPUTS

PAGE 9

| ENTS | | | | - | | 15 |
|--|--------------|-----|-----|----------|-----|------|
| COMPON | BLES | | | | | # |
| CINO | VARIABLES | | | | | 13 |
| (DEFENSIVE | | 12 | 12 | 12 | 12 | m |
| FOR SHIP | L001C | AND | AND | AND | AND | S.O. |
| BOOLEAN FUNCTIONS FOR SHIP (DEFENSIVE UNIT) COPPONENTS | FUNCTION NO. | m | 13 | * | 15 | 11 |

| PAGE 10 | LAUNCHERS FINST NO. 1 1 1 2 1 1 | SECTOR WIDTH | SECTOR #IDT1 | | Z | Z. | | 9 |
|----------------------------|--|--|--------------------------------------|-------------------------|----------------|--|-------------|----------------------|
| a. | FIAUN | SEC *I | SEC | | SIM. OPTION | SIM. OPTION | | SALVO |
| | CHAN. | RIGHT | RIGHT BOUNDARY | | RADAR NO. | G.C. GROUP | | LAUNCHER NO. |
| | FIRST 3 | RADAH NO• | LAUNCHER NO. | | SIM. OPTION | NO1190 | | SALVO |
| | G.C. GROUPS FIRST NO. 1 1 2 | αI | | | RADAR NO. | G+C+ GROUP | | LAUNCHER NO. |
| | PADDARS FIRST NO. F 1 1 2 2 1 | F SECTOR NY WIDTH | T SECTOR | SNS | SIM. OPTIO | SIX. OPTION | | SALVn l Size |
| TION | | RIGHT | S R RIGHT BOUNDARY | SELECTIONS | RADAR NO. | G.C. GROUP | ES | LAUNCHER NO. |
| T INFORMA | ING TEWA EES GROUP 5 1 5 1 | RADAR SCAN SECTORS CTOR RADAR 1074 NO. | FIRE ZONES LAUNCHER NC. | EL OPTION | SIM. | NOTI GO | SALVO SIZES | SALVO L Size |
| DEFENSIVE UNIT INFORMATION | HEADING 2 DEGREES 0.000 35 0.000 35 | RADAR SCA MIDTH 360.0 | LAUNCHER SECTOR #IDTH 360.0 | SIMULATION MODEL OPTION | RADAR NO. | G.C. GROUP | LAUNCHER | LAUNCHER NO. |
| DEFE | | RIGHT SE | RIGHT SE | RACAR SIMUL | ×011 ₩ | ************************************** | | SIZE |
| | X Z-000 1.000 Z-500 1.000 Z-000 1.000 | KADAR R NO. BOU | LAUNCHER R NO. BOU | α | RADAR | G-C. GROUP | | LAUNCHER NO. |
| | | . x - | LAU | | SIM. OPTION | SIM. OPTION | | SALVO SIZE 1 |
| | ART CNE SHIP CNE SHIP TWO AREA CENTER | SECTOR MIDTH 360.0 | SECTOR MIDTH 360.0 | | RACAR ACAR | 6.C. 6.C. 2 | | LAUNCHER NG. 2 |
| | UNET NAN TEST FEST VETAL | BOUNDARY 0.0 | RIGHT Boundary 0.0 | | SEM. OPTION | STR. OPTION | | SALVO SIZE 1 |
| | DEFENSIVE NO. TYPE 1 2 2 2 | RADAR NO• | LAUNCHER NO. | | RADAR NO• | 6.C. BROUP | | LAUNCHER NO. 1 |

DEFENSIVE UNIT INFORMATION

INTERSHIP COMMUNICATIONS LINK STATUS DATA

THE INITIAL LINK STATUS
LEGEND I - LINK INITIALLY IN
0 - LINK INITIALLY OUT

TRANSMITTING DEFENSE LNIT NUMBER

RECEIVER TRA NUMBER 1 1 I

ALL OF THE LINKS MAY BE MODIFIED

DEFENSIVE UNIT INFORMATION

WIND SPEED 20,000 METERS/SECOND

ALTITUDE 5000,000 METERS

NOMINAL REFLECTION COEFFICIENT 0.900

ENVIRONMENTAL DATA

| | | | | | | | MFP | 0.000 | | 20.000 | | |
|----------------------------|--|-----------------|----------------------------|--------------------|------------|-------------|--------------------------------------|----------------------|--------------------|-----------|--|------------------------|
| PAGE 13 | DISTANCE 1 KFT | | 2 | | 1470.05 | ⊢ α α | DISPLACEMENTS FROM MFP | 00000 | | -30.000 | | |
| | SPEED 4 FT/SEC | | | | 3.00 14 | 4 | DISPL | 000.0 | | -2.000 | | |
| | ALTITUDE 2 KFT | | | > | 00 • 0 | | AIM POINT | | S | | | 00 |
| | | 2500.0 | | * | 00 • 6 | | × | | 10 | | 0 0 | 10 0 |
| WATION | 0110 | 30•0 | ZO I | } - | 635 250 | رد. الما | LAUNCH PARAMETERS NODE DISP. INT. | | 0 0 0 0 0 0 | ; ; | 20 20 20 20 20 20 20 20 20 20 20 20 20 | 10 50 |
| OFFENSIVE UNIT INFORMATION | | 2 0 00•0 | OFFENSIVE UNIT INFORMATION | . 2 | 30.00 | < ≪ α | PAF | - | • • • • | | | N N |
| OFFENSIVE | | | OFFENSIVE | > | # 500 • 00 | | A GUID. | | | • | 00 | 00 |
| | AL | 50.00 | | * | 00 | | ECM SHIP GROUP ATKD. | • | 000 | | 00 | 00 |
| | THETA 1 CEGREES | 30.0 | | } - | 10.00 | | | | | | | |
| | PTIONS SPEED 1 FT/SEC 2500.0 | 2500.0 | | 7 | 00•0c | | E NAME | MOCK BEAR Missile | MISSILE MISSILE | MOCK BEAR | MISSILE | MISSILE MISSILE |
| | TLE DESCRI NO. OF LEGS | m | | MT PATH | -1000.00 | | TARGET TYPE | | | n o | | 0 0 |
| | WEAPON PROFILE DESCRIPTIONS PROFILE NO. OF SPEE NUMBER LEGS FT/5 | N | | MASTER FLIGHT PATH | 00.0 | s | 167 100 1 | | | ro 4 | 0 ~ (| 1 00 0 7 |

REPLICATION DATA WAS WRITTEN ON FILE NO. 2

TDHS Sample Pregame Processor Input Deck

| | _ | _ | | | | | |
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| C | Ō | SAMPLE SCENARIO | 0 0 | 0 0 | 1 1 | 0 0 | 0 0 |
| TR | i | AIR SEARCH RADAR | 1 1 | 0 0 | 12 1536 | 0 0 | 0 0 |
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| TRF | 3 | <u> </u> | 2.500 | | .300 | | • |
| TRF | , | | | 6.000 | | 25.000 | •100 |
| | • | .123 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| TS | 1 | RADAR ONLY FRIGATE | 1 1 | 0 0 | 0 4 | 0 0 | 0 0 |
| TSR | S | 1 0 0 0 | 0 0 | 0 0 | 0 0 | 0 0 | 0 0 |
| TST | 0 | 1 0 11 0 | 11 0 | 11 2 | 11 1 | 0 0 | 0 0 |
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| | ĭ | NEUTERED DESTROYER | 2 0 | 0 0 | o o | 0 0 | o o |
| | Ξ. | NEUTERED FRIGATE | | - | • • | | |
| | 1 | | | 0 0 | 0 0 | 0 0 | 1 |
| TS | Ĩ | NEUTERED CARRIER | 4 0 | 0 0 | 0 0 | 0 0 | 0 0 |
| | Õ | CHAFF | 1 1 | 0 0 | 0 0 | 0 0 | 0 0 |
| | Ö | รงว | 2 0 | 5 10 | 10 20 | 10 0 | 0 0 |
| TE | Õ | RECON SOJ | 3 0 | 10 50 | 100 100 | 80 0 | Ò n |
| | Õ | AIRCRAFT | 1 1 | 5 1 | 2 0 | 0 0 | Ó Ó |
| | ~ | ▲ . | 10.000 | _ | | • | • |
| | Õ | | | 10.000 | 10.000 | -0.000 | -0.000 |
| TC | Q | MISSILE (ASM) | 2 1 | 5 1 | 1 0 | 0 0 | 0 0 |
| | Õ | 1.000 1.000 | 1.000 | 1.000 | 1.000 | -0.000 | -0.000 |
| TC | 0 | MISSILE (SSM) | 4 1 | 5 1 | 1 0 | 0 0 | 0 0 |
| TCD | Ö | 2.500 2.500 | 2.500 | 2.500 | 2.500 | -0.000 | -0.000 |
| TC | Õ | SUBMARINE | 3 1 | 5 1 | 2 0 | 0 0 | 0 0 |
| | õ | 0.000 0.000 | 0.000 | 0.000 | 0.000 | -0.000 | -0.000 |
| | - | 0.000 | | | | | 4 |
| | Õ | Acu | 1 1 | 1 0 | 0 0 | 0 0 | Ų O |
| | Õ | ASM | 2 2 | 2 40 | 100 0 | 1500 10 | 0 0 |
| | Ö | SUBMARINE | 3 3 | 3 0 | 0 0 | 0 0 | 0 0 |
| TT | Ō | SSM | 4 4 | 4 30 | 80 0 | 2500 10 | 0 0 |
| TT | Õ | | 5 5 | 1 0 | 0 0 | 0 0 | 0 0 |
| | Ô | | 6 6 | 1 0 | 0 0 | 0 0 | 0 0 |
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| | i | | 2 2 | | 24.000 | | |
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| | 1 | | 4 2 | 0 0 | 24.000 | 180.000 | • 060 |
| | 1 | DDG-Y | 5 2 | 0 0 | 24.000 | 240.000 | •060 |
| DF | 1 | DLG-Z | 6 3 | 0 0 | 24.000 | 300.000 | •070 |
| DF | 1 | CVA | 7 4 | 0 0 | 0.000 | 0.000 | .120 |
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| | Ö | | | | 0.000 | | |
| | Õ | | 0 0 | 0 0 | 0.000 | -7.333 | 0.000 |
| RA | Õ | 1 0 2 0 | 0 0 | 0 0 | .250 | 0.000 | 0.000 |
| | Q | 2 0 1 7 | 2 0 | 2 7 2 7 | -0.000 | -0.000 | -0.000 |
| | Õ | 2 0 1 7 | 2 60 | 2 7 | -0.000 | -0.000 | -0.000 |
| | Ō | 1 0 2 0 | 0 0 | 0 0 | 250 | 7.333 | 0.000 |
| | Õ | 2 0 1 7 2 0 1 7 1 0 2 0 2 0 1 7 2 0 1 7 | 2 10 | 2 7 | -0.000 | -0.000 | -0.000 |
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| RA Õ | 1 0 | 2 0 | U O | 0 0 | •750 | 14.667 | 0.000 |
|---------------------------------------|------------|------------|---------|------------|---------------|---------------|----------------|
| | _ | 1 7 | 2 20 | 2 7 | -0.000 | 1.000 | -0.000 |
| | | | | | | | |
| RAP j | 2 0 | 1 1 | 2 80 | 2 7 | -0.000 | -0.000 | -0.000 |
| RA Õ | 1 0 | 2 0 | O O | 0 0 | 750 | 22.000 | 0.000 |
| RAP 0 | 2 0 | 1 6 | 2 30 | 2 7 | -0.000 | -0.000 | -0.000 |
| ¥ | | | 2 90 | | | | -0.000 |
| RAP Ö | 2 0 | 1 7 | - | | -0.000 | -0.000 | |
| RA Ō | 1 0 | 2 0 | U O | 0 0 | 1.250 | 29.333 | 0.000 |
| | 2 0 | 1 7 | 2 40 | 2 7 | 1.000 | -0.000 | -0.000 |
| × | | | | | - • • • • | * * * * * . | -0.000 |
| RAP Ö | 2 0 | 1 7 | 2 100 | | -0.000 | -0.000 | |
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| | 2 0 | 1 7 | 2 50 | 2 7 | -0.000 | -0.000 | -0.000 |
| ¥ | | | 2 110 | 2 7 | -0.000 | -0.000 | -0.000 |
| RAP Q | _ | 1 7 | | | | 4 | |
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| RMF 0 | -360.000 | 720.000 | 325.000 | 30.000 | 733.333 | 600.000 | 325.000 |
| · · · · · · · · · · · · · · · · · · · | 30.000 | 733.333 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| ¥ . | | | | | | | |
| RA Q | 6 2 | 0 0 | 0 0 | 0 0 | 0.000 | -7.333 | 0.000 |
| RA Ö | 1 0 | 2 0 | Ú O | 0 0 | •250 | 0.000 | 0.000 |
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| z | <u>-</u> | - | | | | | -0.000 |
| RAP 0 | | 1 1 | | | -0.000 | -0.000 | |
| RA Q | 1 0 | 2 0 | 0 0 | 0 0 | 250 | 7.333 | 0.000 |
| RAP 0 | 2 0 | 1 2 | 2 10 | 2 1 | -0.000 | -0.000 | -0.000 |
| | 2 0 | | 2 70 | ž i | -0.000 | -0.000 | -0.000 |
| RAP Q | | | | | | | |
| RA 0 | 1 0 | 2 0 | 0 0 | 0 0 | •750 | 14.667 | 0.000 |
| RAP Õ | 2 0 | 1 6 | 2 20 | 2 6 | -0.000 | -0.000 | -0.000 |
| RAP 0 | 2 0 | 1 6 | 2 80 | 2 6 | -0.000 | -0.000 | -0.000 |
| | | | | | | | |
| RA 0 | 1 0 | S 0 | 0 0 | 0 0 | 750 | 22.000 | 0.000 |
| RAP Q | 2 0 | 1 5 | 2 30 | 2 6 | -0.000 | -0.000 | -0.000 |
| RAP 0 | 2 0 | 1 6 | 2 90 | 2 6 | -0.000 | 1.000 | -0.000 |
| | 1 0 | | 0 0 | 0 0 | 1.250 | 29.333 | 0.000 |
| RA Õ | 1 0 | | 9 0 | 0 0 | | | |
| RAP Õ | 2 0 | 1 6 | 2 40 | 2 6 | -0.000 | -0.000 | -0.000 |
| RAP 0 | 2 0 | 1 6 | 2 100 | 2 6 | -0.000 | 1.000 | ~0.000 |
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| _ % | | | ž 50 | | | -0.000 | -0.000 |
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| RAP 0 | 2 0 | 1 1 | 2 110 | 2 2 | -0.000 | -0.000 | -0.000 |
| RM Õ | 0 1 | 3 0 | Ú O | 0 0 | 149.100 | 55.000 | 100 |
| | 400.000 | 150.000 | 55.000 | 100 | 5.000 | 150.600 | 55.000 |
| _ | | | | | | | |
| RMF 0 | 100 | 5.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| RA Õ | 3 0 | 6 0 | 0 0 | 0 0 | 0.000 | 0.000 | 0.000 |
| | 4 0 | 2 7 | 2 0 | 2 7 | 1.000 | -0.000 | -0.000 |
| ¥ | | 2 7 | 2 10 | 2 7 | -0.000 | -0.000 | -0.000 |
| RAP 0 | | | 2 20 | | | | |
| RAP Ö | 4 0 | 2 7 | 2 20 | 2 7 | -0.000 | -0.000 | -0.000 |
| RAP a | 4 0 | 2 7 | 2 30 | 2 7 | -0.000 | 1.000 | ~0.00 0 |
| | 4 0 | 2 7 | 2 40 | 2 7 | -0.000 | -0.000 | -0.000 |
| <u>~</u> | | | | | | | -0.000 |
| RAP Q | 4 0 | 2 7 | 2 50 | 2 7 | -0.000 | -0.000 | |
| RM 0 | 0 1 | 5 0 | 0 0 | 0 0 | 1200.000 | 10.000 | 25.000 |
| RMF 0 | -660.000 | 900.000 | 10.000 | 25.000 | 833.333 | -0.000 | -0.000 |
| . | | | υ O | 0 0 | 0.000 | 0.000 | 0.000 |
| ¥ | | • | - | - | | : | |
| RX ñ | 0 0 | 0 0 | U O | 0 0 | -0.000 | -0.000 | -0.000 |

RADAR TYPES

CROSS SECTION GROUPS

MODEL NUMBER

MODEL NUMBER

MODEL NUMBER

NUMBER OF COLUMNS = 1

NUMBER OF ROWS = 5

OPTION 1

GROUP NUMBER 3

0.000

0.000

000.0

000.0

ARRAY TRANSPOSE

| | 10.00c | 1.000 |
|---------------------|-----------------|-------------------------------|
| - | 3.0 | |
| 88 | | H |
| NUMBER OF COLUMNS # | 10.000 | NUMBER OF COLUMNS # 1 |
| e. | 07 | 0F 1 |
| | 10.000 | 1.00 |
| | | un = |
| S | | ν S |
| ROW | 10.000 | OF ROW |
| 9 | 9 | 0F |
| NUMBER OF ROWS = 5 | | NUMBER OF ROWS = 5 |
| - | 10.000 | 1.000 |
| OPTION | OSE | NO I |
| | ARRAY TRANSPOSE | UMBER 2 OP ARRAY TRANSPOSE |
| GROUP NUMBER | ARRAY | GROUP NUMBER ARRAY |
| GROUP | | GROUP |
| | | |

MODEL NUMBER 2,500 NUMBER OF COLUMNS = 1 2,500 2,500 OPTION 1 NUMBER OF ROWS # 5 2.500 2.500 ARRAY TRANSPOSE GROUP NUMBER 4

TYPE GENERATOR INPUTS SHIP TYPE HUNGER 1. RADAR ONLY FRIGATE

PAGE

NUMBER OF SCANNING RADARS # 1

RADAR TYPE

NO*
NAME

A AIR SEARCH RADAR

0
0
45

VULNERABILITY

TRACK SUPERVISOR
LOCAL RADAR SCOPE LIMIT SCOPE
NO. FACTOR LIMIT

NUMBER OF DET/TRK OPERATORS = 4

DET/TRK OPERATORS
LOCAL RADAR SCOPE LIMIT SCOPE
NO. FACTOR LIMIT

NUMBER OF GUIDANCE CHANNELS # 0 NUMBER OF GUIDANCE CHANNEL GROUPS = 0

NUMBER OF MISSILE LAUNCHERS = 0

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TYPE GENERATOR INPUTS

NEUTERED DESTROYER SHIP TYPE NUMBER 2.

NUMBER OF SCANNING RADARS # 0

NUMBER OF GUIDANCE CHANNELS # 0 NUMBER OF GUIDANCE CHANNEL GROUPS # 0

NUMBER OF MISSILE LAUNCHERS # 0

TYPE GENERATOR INPUTS

• PAGE

SHIP TYPE NUMBER 3, NEUTERED FRIGATE

NUMBER OF SCANNING RADARS . 0

NUMBER OF MISSILE LAUNCHERS = 0

NUMBER OF GUIDANCE CHANNELS # 0 NUMBER OF GUIDANCE CHANNEL GROUPS # 0

TYPE GENERATOR INPUTS

SHIP TYPE NUMBER 4. NEUTERED CARRIER NUMBER OF SCANNING RADARS = 0 NUMBER OF GUIDANCE CHANNELS = 0 NUMBER OF GUIDANCE CHANNEL GROUPS = 0

NUMBER OF MISSILE LAUNCHERS #

PAGE

TARGET TYPES

| o | | | | |
|--|---|--------------------------|---|----------------|
| PAGE | FIRST NO. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | | * IDTH | 7 |
| a. | FIRST NO. | | SECTOR *IDTH | SIM. OPTION |
| CITY DEV. | | | RIGHT UNDARY | RADAR NO. |
| STD. DEV. | | | RIGHT BOUNDARY | S S |
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| ⊁ II. | V 00000000 | | UNDARY WIDTH NO. BOUNDARY NO. BOUNDARY RADAR SIMULATION MODEL OPTION SELECTIONS | SIM. OPTION |
| VULNERABILITY GROUP 1 2 3 4 4 6 6 | POSITION 1122.000 122.0000 122.00000000000000000 | | RIGHT BOUNDARY RADAR | |
| OLN GE | | TORS | | RADAR NO. |
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| | • • | DETZTRK OP FIRST 1 | | SIM. OPTION |
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| M Z Z Z | 4E | | SECTOR WIDTH 360.0 | RADAR NO. |
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| v | NIT VAME DLG-U DDG-V DDG-Y DDG-Y DLG-Z CVA | SUPE | RIGHT BOUNDARY 0.0 | SIM. OPTION |
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| ת ע | Y Y | DEFENSIVE UNIT | RADAR 100 | RADAR NO. |
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INTERSHIP COMMUNICATIONS LINK STATUS DATA

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| NI O | MIT 3 | нинины |
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| | ECEIVER NUMBER | - 0.64 B O F |
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ALL OF THE LINKS MAY BE MODIFIED

| PAGE 11 | DISTANCE 1 KFT 180,000 48,000 |
|-------------|--|
| | SPEED 4 FI/SEC 1200.0 1400.0 |
| | ALTITUDE 2 KFT 2.000 .100 |
| | SPEED 3 FT/SEC 1200.0 |
| INFORMATION | THETA 2 DEGREES 9.0 4.0 |
| LINO | SPEED 2 FT/SEC 1200.0 |
| OFFENSIVE | ALTITUDE 1 KFT 30.100 1.000 |
| | THETA 1 DEGREES 50.0 2.0 |
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| | DFILE DESCRI NO. OF LEGS 4 |
| | *EAPON PROFILE DESCRIPTIONS PROFILE NO. OF SPEED NUMBER LEGS FT/SEI 1 4 1200 |

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|----|----|

| PAGE 12 | | T F F S C C C C C C C C C C C C C C C C C |
|----------------------------|---|--|
| α. | 163.64 | AIRCRAFT DISPLACEMENTS FROM MAND FAILURE PROBABILITIES (*) X AND FAILURE PROBABILITIES (*) 75.712 |
| | 30°00 | AIRCRAFT D AND FAILUR X 75.712 6.205 0.000* 0.000* 0.000* 0.000* 0.000* 15.801 1.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* 0.000* |
| | , 491.49 | |
| | × *344•15 | E S LAUNCH PARAMETERS NODE DISP. INT. 2 0 0 2 2 10 2 2 80 2 2 80 2 2 90 2 2 90 2 2 100 2 2 50 2 |
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| | MASTER FLIGHT PATH X X Y *564.40 806. | TARGETS NO. 100 TARGETS 100 T |
| | MAS. | 4 4 5 |

| PAGE 13 | | E F F F F F F F F F F F F F F F F F F F | PAGE 14 | TS FROM 4FP (*) 2 (*) 2 (*) 0.000 (* |
|----------------------------|-------------------------------|---|--|--|
| _ | 393.64 | ISPLACEMENT | 7 700•00 | ISPLACEMENT PROBABIL: 0.000 0.000* 0.000* 1.000* 0.000* |
| | 30.00 30.00 | AIRCRAFT DISPLACEMENTS FROM AND FAILURE PROBABILITIES (* **205 | 210 | AIRCRAFT DISPLACEMENTS FROM MAND FAILURE PROBABILITES (*) *** **A *** **A *** *** *** *** *** ** |
| | Y 491.49 | 44 1 1 1 1 | , 96 • 38 86 98 | |
| | × 4. 0. | E S LAUNCH PARAMETERS NODE DISP. INT. 2 60 2 2 70 2 2 70 2 2 80 2 2 90 2 2 90 2 2 100 2 5 50 2 | 96. ×.6. | METERS INT. |
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| INFORM | 30.00 | α | INFORM Z =.10 | α 4 34 g α 3 g α 3 g α 4 α α α α α α α α α α α α α α α α α α |
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| | 30.00 | | 2 10 | <u>u</u> |
| | PATH ∀ 944.21 | NO PROBLEM | PA7H 4 ∀ Y 85.52 | TYPE NAME SUBMARINE SSM SSM SSM SSM SSM SSM SSM SSM |
| | | 74 NO | | 7 A A A G E T A A A A A A A A A A A A A A A A A A |
| | MASTER FLIGHT X -661.14 | TARGETS 161 23 23 24 23 24 23 34 34 35 36 36 37 39 39 | MASTER FLIGHT X 122.14 | TARGETS TGT NO. 00. 40. 42. 44. 45. 46. 46. |

| PAGE 15 | L Z | AIRCRAFT DISPLACEMENTS FROM WFP AND FAILURE PROBABILITIES (*) X Z U.000 0.000 0.000 |
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| | > | |
| 101 | Z T X Z5.00 -300.00 | P A R A S I T E S GUID. WPN. LAUNCH PARAMETERS REQ. PRF. NODE DISP. INT. SCEN |
| ORMA | | ω × π • • |
| IN IN | 2 25°C | 430 430 |
| OFFENSIVE UNIT INFORMATION | ۲ 886,33 | P A SHIP ATKD. GUID ACT. INT. REG. A ASMD SCEN |
| ō | T X Y 0.00 156.28 886.33 | SHIP ACT P |
| | T -660.00 | ECM GROUP 3 |
| | 2 25.00 | ID OF FILE |
| | ER FLIGHT PATH X Y Y 208,38 1181.77 | RGET TYPE NAME |
| | MASTER FLIGHT PATH X Y Y 208.38 1181. | TARGETS TGT TARGET TY NO. NO. 47 S |

REPLICATION DATA WAS WRITTEN ON FILE NO.

Appendix I

MAIN SIMULATION PROCESSOR INPUT CARD FORMATS

Appendix I

MAIN SIMULATION PROCESSOR INPUT CARD FORMATS

Nine input card types are defined for the MSP, five of which are unique to the TDHS version of the model. The first input cards (one each of the first two types) are always required and up to 18 additional cards (of the next two types) may be required, depending on option selections specified on the first input card. In the TDHS version, these are followed by at least one each of the remaining five input card types.

The structure of an MSP input deck is as follows:

(exactly one) Card Type GC,
(exactly one) Card Type GP,
(either no or one) Card Type GE,
(either no or 17) Card Type GR,
(at least one) Card Type GTP,
(at least one) Card Type GSF,
(at least one) Card Type GBT,
(at least one) Card Type GRE,
(at least one) Card Type GRE,

The requirement for Card Type GE is dictated by the event-listing-subset option specified in columns 55-56 of Card Type GC. Similarly the random-number-initialization option specified in columns 61-62 of Card Type GC determines the requirement for the input cards of Type GR.

Each of the nine card types is described on the following pages.

Description of Card Type GC

The first input card to the MSP specifies the selection of several input, output, and replication control options together with a 20-character run identifier.

| Card Columns | Format | Description |
|--------------|--------|--|
| 1-2 | A2 | The label "GC" indicating that this is the game control card. |
| 6-25 | 2A10* | An alphanumeric description of the run or replication series (e.g., date, identification number, or purpose). |
| 26-30 | 15 | The total number of replications of this game situation to be made (including those that may have been previously made). |
| 31-35 | 15 | The number of replications of this game situation previously made. If greater than or equal to the contents of columns 26-30 above, no additional replications will be made and the game will be terminated immediately. |
| 36-40 | 15 | Magnetic tape file number of replication data to be used for this run. If this field is left blank or set to 0, the first replication file will be used. Note that the initial file on tape is the type data file which is skipped over. |
| 41-45 | 15 | Not presently used. |
| 46-50 | 15 | Not presently used. |
| 51-52 | 12 | Option selection for detailed prereplication listing of type data, defense information, and offense information. Note that the run identifier, option selections, game parameters, and initial random number array will always be printed. |

Description of Card Type GC (Continued)

| Card Columns | Format | Description |
|----------------|--------|--|
| 53-54 | 12 | Option selection for the printing of a detailed replication summary. Note that some information will always be printed at the end of each replication (e.g., random number array). |
| 55-56 | 12 | Option selection for the subset of event types of interest for detailed printout as specified in columns 57-58 and 59-60. |
| | | 0 or blank $\frac{No}{or}$ event occurrences, insertions, or deletions are to be listed (and Card Type GE is not required) |
| | | All event types are of interest (and Card Type GE is not required) |
| | | Some event types are of interest as specified on Card Type GE (which must then be the third card in the MSP input deck). |
| 57-58 | 12 | Option selection for listing occurrences of events of interest (as specified above) during a monitoring time interval specified on Card Type GP. |
| 59-60 | 12 | Option selection for listing insertions to and deletions from the event calendar over the monitor time interval. |
| 61 - 62 | 12 | Option selection for initialization of the random number generator. |
| | | O or blank Causes standard initialization of the random number array by subroutine RANSET (and no input cards of Type GR are required) |

Description of Card Type GC (Concluded)

| Card Columns | Format | Description | |
|--------------|------------|---|--|
| • . | | Nonzero | Causes values to be read from cards of Type GR for initial-ization of the random number generator array. |
| 63-64 | 12 | Option selection for punched card output the random number generator array values the completion of the final replication. Note that these values are always printer at the end of every replication. | |
| | | 0 or blank | Punched card output is not desired |
| | | Nonzero | Cards of Type GR, suitable for input to some later run, will be punched. |
| 65-70 | <i>I6</i> | The number of random numbers to be generated and discarded prior to initiation of game play. | |
| 71-72 | <i>I</i> 2 | Option selection outputs. | on [†] for printing special debugging |

0 or blank Not desired on any replication 1 Desired on the first replication only 2 or more Desired on all replications.

^{*}The format shown is for a machine capable of storing 10 BCD characters in each of two computer words (see N20BCD in common block IO).

[†]Option selections are as follows:

Description of Card Type GP

The second input card to the MSP is used to specify several delay time values, a maximum simulation time, and an event monitoring time interval.

| Card Columns | Format | Description |
|--------------|--------|---|
| 1-2 | A2 | The label "GP" indicating that this is the game parameter card. |
| 6-15 | F10.3 | Starting time of the time interval over which monitoring (i.e., printer listing) of event occurrences, deletions, and insertions will apply. If 0 or left blank, the game start time will be used. Note that if columns 55-56 of Card Type GC contain 0 or if columns 57-58 and 59-60 both contain 0, then the monitor time interval defined here has no effect. |
| 16-25 | F10.3 | Ending time of the monitoring time interval. If 0 or left blank, the maximum simulation time value (below) will be used. |
| 26-35 | F10.3 | Maximum simulation time, in seconds. When- ever the next event game time exceeds this value, the simulation process will be halted (i.e., this is one of the conditions that may determine the end of a replication). |
| 36-45 | F10.3 | Initial reaction time, in seconds. This delay from first detection to earliest possible weapon assignment is applied once to each ship group having firepower capability. The first TEWA (threat evaluation and weapon assignment) event for each ship group is scheduled at a time determined by this delay added to the time of first detection with respect to the detecting defense unit. This value must be nonnegative or an error message will result. |

Description of Card Type GP (Concluded)

| Card Columns | Format | Description |
|--------------|--------|--|
| 46-55 | F10.3 | The TEWA interval, in seconds. The TEWA event for each defense unit is a recurrent or periodic type of event which, after its first occurrence (see above), reschedules itself according to the value of the time interval specified here. This value must be greater than zero or an error message will result. |
| 56-65 | F10.3 | The intership communications delay, in seconds. This is the expected value of the time required for a defense unit making a radar detection to pass the detection information to all other defense units with which it is able to communicate. This value must be non-negative or an error message will result. |

Description of Card Type GE

This card is included in the MSP input deck only if some, but not all, of the event types are of interest for the purpose of detailed printer listing during the event monitoring time interval (this corresponds to columns 55-56 of Card Type GC containing the value 2).

| Card Columns | Format | Description |
|--------------|-----------|--|
| 1-2 | A2 | The label "GE" indicating that this is the card defining the event types of interest for detailed printer listing. |
| 5 | I1 | The indicator for event type 1, where 0 or blank means that this event type is not of interest and a nonzero entry means that the event type is of interest. |
| i + 4 | : 11 | The indicator for event type i, interpreted as above. The dictionary of event types by number and mnemonic is contained in Appendix J. |

Description of Card Type GR

Cards of this type are included in the MSP input deck only if a particular initialization of the random number generator is desired (this corresponds to columns 61-62 of Card Type GC containing a nonzero value). A total of 17 cards are required when the use of this card type is specified.

First Card:

| Card Columns | Format | Description |
|--------------|-------------|--|
| 1-2 | A2 | The label "GR" indicating that this is a random number generator initialization card. |
| 3-4 | 12 | The value "1" indicating that this is the first of a sequence of GR cards. |
| 5-20 | 116 | Integer starting value for the sequence X (where $X_{i+1} = A_i * X_i + C_i modulo M$) used to calculate the initial random number table entries and subsequent replacement values. |
| 25-40 | I 16 | Integer starting value for the sequence Y (where Y = $A_2 * Y_1 + C_2$ modulo M) used by function RAND to obtain an index to the random number table. |

Cards 2 through 17:

| 1-2 | A2 | The label "GR". |
|-------|-----|---|
| 3-4 | 12 | The value i (i = 2 , 17) indicating the card sequence number. |
| 5-20 | 116 | The (4i-7)th entry in a 64 word auxiliary random number table. |
| 25-40 | 116 | The (4i-6)th entry. |

Description of Card Type GR (Concluded)

| Card Columns | Format | | Description |
|---------------|--------|--------------|-------------|
| 45- 60 | 116 | The (4i-5)th | entry. |
| 65-80 | 116 | The (4i-4)th | entry. |

Description of Card Type GTP

One card of this type is necessary for describing the tracking parameters.

| Card Columns | Format | Description |
|--------------|-----------|---|
| 1-3 | A3 | The label "GTP" indicating that this is a tracking parameter card. |
| 6-10 | <i>I5</i> | Option selection for the form of the reachable set where 0, blank, or 1 means a circle and 2 means an ellipse. |
| 11-15 | <i>I5</i> | The numerator of the eccentricity of the ellipse (leave blank or 0 if the reachable set is a circle). This value must be nonnegative and less than the denominator which is entered in columns 16-20 of this card. |
| 16-20 | <i>I5</i> | The denominator of the eccentricity of the ellipse (leave blank or 0 if the reachable set is a circle). This value must be greater than the numerator specified in columns 11-15. |
| 21-25 | <i>I5</i> | Whenever a track is established, this entry is used as the threshold for determining whether or not an additional tracking operator should be activated. It must be greater than or equal to 1 and at least as large as the deactivation threshold which is entered in columns 26-30 of this card. If the field is blank or 0, a default value of 5 will be assigned. |
| 26-30 | I5 | Whenever a track is dropped, this entry is used as the threshold for determining whether or not a tracking operator should be deactivated. It must be greater than or equal to 1 and less than or equal to the activation threshold entered in columns 21-25 of this card. If the field is left blank or 0, a default value of 4 will be assigned. |
| 31-35 | <i>I5</i> | The minimum time in seconds between attempts to update a given track. A default value of 10 seconds is assigned if the entry is nonpositve |
| 36-40 | <i>I5</i> | The number of successful updates of a given track required to advance the track from tentative to firm status. A value greater than 2 should be entered. If blank or 0, a default value of 5 is assigned. |

Description of Card Type GTP (Concluded)

| Card Columns | Format | Description |
|--------------|------------|---|
| 41-45 | <i>I</i> 5 | The percent by which a candidate track speed must differ from a reference track speed to call it a new track rather than a split from the reference track. Must be nonnegative. |
| 46-50 | I5 | The minimum distance separation in feet for multisymbols. If left blank or 0, a default value of 1000 is assigned. |
| 51-55 | <i>I5</i> | The degree of the least squares fit of the track history data. If blank or 0, a 1st degree fit is assumed. |
| 56-60 | I5 | The number of consecutive missed reports necessary to initiate drop track action. |
| 61-65 | <i>I5</i> | Late detection or late split range in kft. New detection or track splits occurring at less than this range will be considered as late detects or splits. A default value of 240 kft (40 nmi) is assigned if this field is blank or 0. |
| 66-70 | I5 | Smaller boundary in degrees of the primary zone of interest. Must be less than the entry in columns 71-75 of this card. |
| 71-75 | I5 | Larger boundary in degrees of the primary zone of interest. It also is the smaller boundary of the secondary zone of interest. |
| 76-80 | I5 | Larger boundary in degrees of the secondary zone of interest. It must be greater than columns 71-75 of this card. |

Description of Card Type GSF

One Card of this type is necessary for describing the scale factors which are used to increase or decrease the reachable set size. As a rule, the fewer the number of reports in the track history, the larger the reachable set size. The reachable set may be thought of as the region examined by the tracking operator in correlating video with the track to which he is sequenced. This region shrinks as more reports are entered into the track history for a given track.

| Card Columns | \underline{Format} | $\underline{Description}$ |
|--------------|----------------------|--|
| 1-3 | A3 | The label "GSF" indicating that this is a scale factor card. |
| 6-15 | F10.3 | The scale factor to be applied if there is one report in the track history (e.g., 2.25). |
| 16-25 | F10.3 | The scale factor to be applied if there are two reports in the track history (e.g., 2.03). |
| • | • | • |
| • | • | • |
| • | • | • |
| 46-55 | F10.3 | The scale factor to be applied if there are five reports in the track history (e.g., 1.2753). |
| 56-65 | F10.3 | The maximum allowable reachable set radius or major axis in kft. If blank or 0, a default value of 60 kft is assigned. |

If any of the scale factor fields are blank, zero, or negative, a value of 1.25 will be assigned.

Description of Card Type GBT

This card type is available for specifying ball tab errors and/or scope limits for individual tracking operators and for track supervisors. At least one card must be included in the input deck even if default values are desired for all operators. (Such a card would contain GBT in columns 1-3 and a negative value in columns 6-10.)

| Card Columns | Format | $\underline{\textit{Description}}$ |
|--------------|-----------|--|
| 1-3 | A3 | The label "GBT" indicating that this is a ball tab error/scope limit card. |
| 6-10 | <i>I5</i> | The task force identification number (taken from the Pregame Processor output) corresponding to the tracking operator or track supervisor for which the two entries which follow apply. If the operator is a track supervisor, enter the ship number to which the track supervisor is assigned + 1000 (e.g., for the track supervisor aboard ship 7, enter 1007). If this field is left blank or is 0, the two entries following this field will be ignored. A negative entry for an operator number signifies that all values have been read. |
| 11-15 | <i>I5</i> | The ball tab error in thousandths of an inch for the supervisor. A negative entry indicates that the default value of 1/32 of an inch is to used. Note that blank or 0 means zero ball tab error. |
| 16-20 | <i>I5</i> | The scope limit in kft for the designated operator or track supervisor. A negative entry means that the scope limit assigned in the Pregame Processor run will be used. Blank or 0 means that this operator is deactivated. |
| 21-25 | <i>I5</i> | See columns 6-10. |
| 26-30 | <i>I5</i> | See columns 11-15. |
| 31-35 | <i>I5</i> | See columns 16-20. |
| • | • | • |
| 66-70 | I5 | See columns 6-10. |

Description of Card Type GBT (Concluded)

| Card Columns | | Format | Description | | |
|--------------|-------|-----------|--------------------|--|--|
| | 71-75 | <i>I5</i> | See columns 11-15. | | |
| | 76-80 | <i>I5</i> | See columns 16-20. | | |

Use as many cards of this type as are necessary to enter ball tab errors and scope limits for tracking operators and track supervisors to which values are to be assigned. A negative entry for an operator indicates that there are no more entries on the card being read and that no more cards of Type "GBT" follow.

Description of Card Type GRE

This card type is available for specifying range and azimuth sigmas corresponding to radar measurement errors. At least one card must be included in the input deck even if default values are desired for all radar sets. (Such a card would contain GRE in columns 1-3 and a negative value in columns 6-10).

| Card Columns | Format | $\underline{\textit{Description}}$ | |
|--------------|-----------|---|--|
| 1-3 | A3 | The label "GRE" indicating that this is a radar observa- tion error card. | |
| 6-10 | <i>I5</i> | The task force identification number (taken from the Pregame Processor output) corresponding to the radar for which the two entries which follow apply. If this field is left blank or 0, the two entries following this field will be ignored. A negative entry for a radar set number signifies that all values have been read. | |
| 11-15 | <i>I5</i> | Range sigma as a multiple of range resolution. | |
| 16-20 | <i>I5</i> | Azimuth sigma in mils. | |
| 21-25 | <i>I5</i> | See columns 6-10. | |
| 26-30 | | See columns 11-15. | |
| 31-35 | | See columns 16-20. | |
| • | • | • • | |
| 66-70 | | See columns 6-10. | |
| 71-75 | | See columns 11-15. | |
| 76-80 | | See columns 16-20. | |

Description of Card Type GST

| Card Columns | Format | <u>Description</u> |
|--------------|-----------|---|
| 1-3 | A3 | The label "GST" indicating that this is a service time card. |
| 6-10 | I5 | The task force identification number (taken from the Pregame Processor output) corresponding to the tracking operator or track supervisor for which the two entries which follow apply. If the operator is a track supervisor, enter the ship number to which the track supervisor is assigned + 1000 (e.g., for the track supervisor aboard ship 7, enter 1007). If this field is left blank or 0, the two entries following this field will be ignored. A negative entry for an operator number signifies that all values have been read. |
| 11-15 | I5 | The minimum mean value service time in seconds for the designated tracking operator or track supervisor. A negative or 0 entry will result in a default value of 2 for the track supervisor and 4 for the tracking operator. |
| 16-20 | <i>I5</i> | The maximum mean value service time in seconds for the designated tracking operator or track supervisor. A negative or 0 entry will result in a default value of 6 for the track supervisor and 10 for the tracking operator. |
| 21-25 | <i>I5</i> | See columns 6-10. |
| 26-30 | <i>I5</i> | See columns 11-15. |
| 31-35 | <i>I5</i> | See columns 16-20. |
| • | • | • • • |
| 66-70 | <i>I5</i> | See columns 6-10. |
| 71-75 | <i>I5</i> | See columns 11-15. |
| 76-80 | <i>I5</i> | See columns 16-20. |

Use as many cards of this type as are necessary to enter minimum and maximum meanvalue service times for tracking operators and track supervisors to which values are to be assigned. A negative entry for an operator indicates that there are no more entries in the card being read and that no more cards of Type "GST" follow. Appendix J

DICTIONARY OF GAME EVENT TYPES

Appendix J

DICTIONARY OF GAME EVENT TYPES

There are presently 45 event types defined for the simulation model, including 14 unique to the TDHS version. Additional event types may be defined as desired and as the growth and further development of the model dictate. Provision is presently made for 45 event types.

Addition of a new event type requires: entry of the event type number (by mnemonic) in common block EVENTS, insertion of the event type name and relative priority ranking in arrays ENAMES and NPRIOR respectively in common block CALNDR, specification of a new subroutine call corresponding to the event type within the game control routine, and inclusion of the new event routine itself in the program deck.

If more than 45 event types should be needed, the lengths of common blocks CALNDR and EVENTS must be increased, necessitating recompilation of all subroutines using either or both of these common blocks. Ultimately the number of event types is also limited by the field width allowed for the event type within the integer parameter array NCAL of the game calendar. However more than 1000 event types can be accommodated even on a 32-bit word length machine, so this poses no practical limitation to the number of event types that may be defined.

Event type numbers need not correspond to the order of the corresponding mnemonics within common block EVENTS; in fact the main purpose of that common block is to facilitate renumbering event types without requiring recompilation of every subroutine making use of event identifiers.

Table J1 contains a brief description of each of the 45 currently defined event types together with the nature of the two integer parameters associated with each event type.

The interdependence among the event types is illustrated in Tables J2 and J2A. For each event type the tables show which types of events may be generated (inserted in the game calendar) and/or canceled (deleted from the game calendar). Also shown (as event type 0) is the initialization procedure, which gets the game underway by scheduling the first node event for each nonimpacting type target.

Pairwise priorities for various event types are as shown in Tables J3 and J3A. These relative priorities are used to establish the contents of the NPRIOR array in common block CALNDR as shown in the last column of Table J3. The priority values are used only when two or more events are found to occur simultaneously (at exactly equal values of game simulation time). If two simultaneous events are of the same type or are of

types having equal priority values (in the NPRIOR array), then the event most recently inserted into the game calendar will be processed first. In other words the discipline for equal-priority simultaneous events is last in, first out (LIFO).

Table J-1

GAME EVENT TYPES

| Number | Name | 1st Parameter | 2nd Parameter | Description |
|--------|--------|---------------|------------------|--|
| 1 | SCAN | Radar Set No. | Model Option No. | Periodic surveillance radar scan event; re- generates itself after being triggered by an ENTER or a LOSE event |
| 2 | DETECT | Radar Set No. | Target No. | Detection of a target by a surveillance radar set; results from a SCAN event |
| 3 | PASS | Radar Set No. | Target No. | Detection passing event; displaced from correspond- ing DETECT event by a communications time delay |
| 4 | PSSDET | Radar Set No. | Target No. | Secondary detection event resulting from a PASS event |
| 5 | LOSE | Radar Set No. | Target No. | Loss of a primary detec- tion resulting from a LEAVE or DISRDR event |
| 6 | NODE | Target No. | (Unused) | Target passing through a node on its piecewise linear flight path |
| 7 | VANISH | Target No. | (Unused) | Nonimpacting type target arriving at the final node of its flight path |
| 8 | IMPACT | Target No. | Ship No. | Impacting type target arriving at its final node (in the vicinity of the intended defense unit) |

Table J-1 (Continued)

| · | · | | | |
|--------|-----------------|---------------|----------------|---|
| Number | Name | lst Parameter | 2nd Parameter | Description |
| 9 | ASSIGN | Channel No. | Target No. | Assignment of a SAM weapon (identified by a guidance channel number) to an offense unit; scheduled by the TEWA event |
| 10 | L A UNCH | Channel No. | Target No. | Launch of a SAM weapon; scheduled by the corre- sponding ASSIGN event |
| 11 | INTCPT | Channel No. | Target No. | Interception of an offense unit by a SAM weapon; scheduled by the corresponding LAUNCH event |
| 12 | RELEAS | Channel No. | (Unused) | Release of a SAM weapon from a previously held assignment; scheduled by an INTCPT, ABORT, or DROP event |
| 13 | TRNSFR | Channel No. | Target No. | Transfer of a SAM weapon assignment to a different offense unit prior to missile intercept |
| 14 | ABORT | Channel No. | Target No. | Inflight abortion of a SAM weapon assignment |
| 15 | DIE | Launcher No. | Target No. | Attrition of an offense unit caused by a previous SAM weapon intercept against it |
| 16 | TEWA | Ship No. | TEWA Group No. | Periodic threat evaluation and weapon assignment event; regenerates itself after being triggered by the first detection made with respect to the defense unit |

Table J-1 (Continued)

| Number | Name | lst Parameter | 2nd Parameter | Description |
|--------|--------|---------------|--------------------|---|
| 17 | DROP | Channel No. | Target No. | Prelaunch abortion of a SAM weapon assignment |
| 18 | EMERGE | Target No. | Launch vehicle No. | Launch of a parasite offense unit from its parent vehicle |
| 19 | VICTIM | Launcher No. | Target No. | Attrition of a parasite offense unit caused by a previous SAM weapon intercept against its parent vehicle |
| 20 | ENTER | Radar Set No. | Target No. | Entering penetration of the coverage volume of a surveillance radar set by a particular offense unit |
| 21 | LEAVE | Radar Set No. | Target No. | Exiting penetrator of the coverage volume of a surveillance radar set by a particular offense unit |
| 22 | DISRDR | Radar Set No. | J | Surveillance radar set has gone from ON to OFF (J=1) or from OFF to ON (J=0) |
| 23 | DISCHN | Channel No. | J | SAM weapon guidance channel has gone from ON to OFF (J=1) or from OFF to on (J=0) |
| 24 | DISLAN | Launcher No. | J | SAM weapon missile launcher has gone from ON to OFF (J=1) or from OFF to ON (J=0) |

Table J-1 (Continued)

| F | l - | | | |
|--------|--------|---------------|----------------------------|---|
| Number | Name | 1st Parameter | 2nd Parameter | Description |
| 25 | COMEIN | Ship No. | Target No. | Target comes within the assignment range of the weapons aboard a ship |
| 26 | OUTGO | Ship No. | Target No. | Target goes outside the assignment range of the weapons aboard a ship |
| 27 | FAIL | Component No. | Zero | Component fails |
| 28 | DOWN | Component No. | Component Type No | Component goes down because of damage or random failure |
| 29 | REPAIR | Component No. | Component Type No | . A repair cycle begins |
| 30 | DAMAGE | Component No. | (Damage ratio)x 1000 +1 | Component is damaged by a penetrator |
| 31 | UP | Component No. | Component Type No. | Repair cycle is completed and component goes up |
| | | | | · |

Table J-1 (Continued)

| Number | Name | 1st Parameter | 2nd Parameter | Description |
|--------|--------|--|-------------------------|---|
| 32 | TRKSUP | Radar Set No. | Track Supervisor No. | Models the functions performed by the track supervisor; regenerates itself after having been initiated by an ENTER event |
| 33 | TRACKR | Tracking Operator No. | Radar Set No. | Models the functions performed by the tracking operator; regenerates itself after having been initiated by a WAKEUP event |
| 34 | DROPTK | Track Supervisor No. plus an integer bias* | Track No. | Drop track action performed by the track supervisor |
| 35 | SPLITK | Parent Track No. | New Track No. | A split track may occur whenever multiple video correlate with a sequenced track |
| 36 | UPDATE | Tracking Operator No. | Track No. | An updated position report is entered for a track to which a tracking operator has been sequenced |
| 37 | MISSTK | Tracking Operator No. | Track No. | A missed position report is entered if no video correlates with a sequenced track |
| 38 | NEWDET | Tracking Operator No. or Track Super- visor No. plus a bias of 200 | Track No. | A new detection (one that is not a late detect) signifying the establishment of a new track by the track supervisor or by a tracking operator |
| 39 | WAKEUP | Tracking Operator No. | Radar Set No. | A tracking operator is activated |
| 40 | SLEEP | Tracking Operator No. | Track Supervisor No. | A tracking operator is placed in inactive status |
| 41 | PRELF | Target No. | Launch Vehicle No. | Prelaunch failure of a parasite offense unit onboard its parent vehicle |
| 42 | IFFAIL | Target No. | Target No. | Inflight failure of a launched cruise missile |
| 43 | DUD | Target No. | Ship No. | A cruise missile fails to detonate upon impact with a ship |
| 44 | LATEDT | Tracking Operator No. | Track No. | A new detection has occurred at close range and triggers the establishment of a new track by the track supervisor or by a tracking operator |

^{*}The bias value equals 500 if the track has passed outside of the maximum instrumented range of the radar or equals 900 otherwise.

Table J-1 (Concluded)

| Number | Name | 1st Parameter | 2nd Parameter | Description |
|--------|--------|------------------|---------------|--|
| 45 | LATESP | Parent Track No. | New Track No. | A split track has occurred at close range as a result of multiple video correlating with a sequenced track |

Table J2 - Event Generation/Cancellation Matrix

| | | | | | | | ပ | |
|----------|------|--------------------------|--|---|---|--|--|---------------|
| | 31 | | | : | | | ٥/٥ | |
| | 30 | | 5 | | | | | |
| | 29 | | | | | | ტ | |
| | 28 | | | | | | 3/5 | 3/5 |
| | 27 | | | | | | Ŋ | |
| e l | 26 | | G | | | | | |
| type | 25 | | ტ | | | | | |
| this | 24 | | 9 | | _ | | ტ | 9 |
| | 23 | | 5 | | | | ව | 9 |
| s of | 22 | | ტ | | | | _O | · v |
| events | 21 | | 5 | | ວ | | | |
| ev | 20 | | D. | | ວ | | | |
| (0) | 19 | | | | ව | | | |
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| cancel | 17 | | 9 | | ა | ტ ტ | | |
| or c | 16 | 5 5 | | | D. | | ರ ೮ | |
| 1 1 | 15 | | ပပ | ტ | ຽ | | | |
| (g) | 14 | | ა | | ა | 9 | | |
| ate | 13 | | ა ა | | თ თ | ວ | | |
| generate | 12 | | | ა ა | ტ | C | | |
| | 11 | | υ | ტ | ပ ပ | C | | |
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| | 2 (| O | | | | _හ | | |
| | 1 | · · | | | | r. | | |
| s event | Type | SCAN (DETECT PASS PSSDET | LOSE NODE VANISH IMPACT ASSIGN | LAUNCH INTCPT RELEAS TRNSFR ABORT | DIE TEWA DROP EMERGE VICTIM | ENTER LEAVE DISRDR DISCHN DISCHN | COME IN OUTGO FAIL DOWN REPAIR | DAMAGE UP |
| This | No. | 1 2 3 4 4 | 70/86 | 10 11 12 13 14 | 15 16 17 18 19 | 20 21 22 23 23 | 25 26 27 28 28 | 30 |

*The game initialization procedure schedules the first node event for each nonimpacting target.

ADDITIONAL EVENT GENERATION/CANCELLATION MATRIX FOR TDHS MODEL VERSION Table J-2A

| | | | | | | 1 | · · · · · · · · · · · · · · · · · · · | | |
|----------|------|----------------|---------------|-------|----------------------------|----------------------------|---------------------------------------|------------------------|------------------|
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| s event | Type | NODE IMPACT | DIE EMERGE | ENTER | TRKSUP TRACKR DROPTK | SPLITK UPDATE MISSTK | NEWDET WAKEUP SLEEP | PRELF IFFAIL DUD | LATEDT LATESP |
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Table J3-Relative Priorities of Event Types*
(For Simultaneous Event Occurrences)

| (For Simult | | | Jimui Lane | l Eve | iic occurre | l |
|----------------------|--------------------------------------|---------------------|------------------------------------|------------|--------------|---------------------------|
| Co1u | ımn A | Column B | | Co1 | umn C | Relative Priority |
| No. | Name | No. | Name | No. | Name | (NPRIOR Value) |
| 1 2 3 4 | SCAN DETECT PASS PSSDET | 16 1 1 1 | TEWA SCAN SCAN SCAN | 5 | LOSE PASS | .200 250 210 250 |
| 5 6 7 8 | LOSE NODE VANISH IMPACT | 3 1 1 1 | PASS SCAN SCAN SCAN | 9 | ASSIGN | 240 500 500 500 |
| 9 10 11 12 | ASSIGN LAUNCH INTGPT RELEAS | 16 9 10 11 | TEWA ASSIGN LAUNCH INTCPT | 1 5 | DIE | 400 410 430 450 |
| 13 14 15 16 | TRNSFR ABORT DIE TEWA | 15 16 1 | DIE TEWA SCAN | 19 | VICTIM | 460 400 300 100 |
| 17 18 19 20 | DROP EMERGE VICTIM ENTER | 16 1 1 1 | TEWA SCAN SCAN SCAN | | | 400 500 300 500 |
| 21 22 23 24 | LEAVE DISRDR DISCHN DISLAN | 1 2 11 10 | SCAN DETECT INTCPT LAUNCH | 4 | PSSDET | 500 280 440 420 |
| 25 26 27 28 | COME IN OUTGO FAIL DOWN | 26 6 | OUTGO NODE | | | 520 510 550 550 |
| 29 30 31 | REPAIR DAMAGE UP | | | | | 550 550 550 |
| | | | | | | |

^{*}Within each row, the event type shown in column A has priority over a simultaneous event of the type shown in column B or C. The relative priority value for the event type in column A is shown in the last column. A higher priority event will be processed first within the simulation model.

Table J-3A

RELATIVE PRIORITIES OF ADDITIONAL TDHS EVENT TYPES*

(For Simultaneous Event Occurrences)

| | Column A | | Column B | | olumn C | Relative Priority | |
|--|--|--|---|-----|---------|--|--|
| No. | Name | No. | Name | No. | Name | (NPRIOR Value) | |
| 32 33 34 35 36 37 38 39 | TRKSUP TRACKR DROPTK SPLITK UPDATE MISSTK NEWDET WAKEUP | 33 16 33 36 38 38 33 33 | TRACKR TEWA TRACKR UPDATE NEWDET NEWDET TRACKR TRACKR | | | 260 200 220 250 230 230 210 210 | |
| 40 41 42 43 44 45 | SLEEP PRELF IFFAIL DUD LATEDT LATESP | 34 6 6 8 33 36 | DROPTK NODE NODE IMPACT TRACKR UPDATE | | | 230 510 510 510 210 250 | |

^{*}Within each row, the event type shown in column A has priority over a simultaneous event of the type shown in column B or C. The relative priority value for the event type in column A is shown in the last column. A higher priority event will be processed first within the simulation model.

Appendix K

SAMPLE RUN EVENT OCCURRENCE AND REPLICATION SYMMARY LISTING

Appendix K

SAMPLE RUN EVENT OCCURRENCE AND REPLICATION SUMMARY LISTING

This appendix presents the two listings of the printer output produced by the Main Simulation Processor when the Pregame Processor outputs from the two sample input decks described in Appendix H are combined with suitable MSP control variables as specified in Appendix I. As in Appendix H, no particular importance should be given to the exact numerical values used in these demonstration cases, since many values are fictitious so as to keep the material unclassified. The first MSP output listing is a result of the parent model, and the second a result of the TDMS version.

The first portion of each output listing consists of a recapitulation of the control variables specified for this particular run. This is followed by the defense and offense unit descriptions just as they were printed in the PGP outputs.

Next comes the optional event occurrence listing, which shows the actual sequence of events, including insertions and deletions from the game calendar, that constitutes a play of the game. This is followed by a statistical tabulation of the number of occurrences of each event type experienced in the replication, together with the total real time consumed by each event type, the average time per occurrence, and the percent of total running time represented by each event type. It should be emphasized that the current version of the TDHS model simulates only the detection and tracking process, so that no events related to assignment of defensive weapons appear in the second output listing. The maximum and average calendar sizes are given and the terminal values in the random number generator are tabulated.

Finally, there are eight summary tabulations of the outcome of the replication (the eighth appearing only in the TDHS version), one for each of the following categories:

- 1. By guidance channel group,
- 2. By missile type,
- 3. By radar set.
- 4. By defense unit,
- 5. By nonimpacting target,
- 6. By parasites which are killed prior to impact,
- 7. By parasites which are not killed,
- 8. By track history.

Additional tabulations or other data within existing breakdowns could of course be added to the printer output listing as the requirements of a particular analysis dictate.

GAME IDENTIFICATION --- DEMONSTRATION CASE 1 --- PARENT MODEL

TO BE I REPLICATIONS OF THIS GAME SITUATION. THERE ARE OF WHICH

MAGNETIC TARK FILE 1 HAS BEEN USED FOR THIS BUNATHE FILE IDENTIFICATION IS --- SAMPLE TEST CASE

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EVENT OCCURRENCES WILL BE PRINTED FOR ALL REPLECATION(S).

EVENT INSERTIONS AND DELETIONS WILL BE PRINTED FOR ALL REPLIGATION(S).

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EVENT TYPES TO BE MONITORED ARE AS FOLLOWS-

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RANDOM NUMBER GENERATOR ARRAY VALUES WILL NOT BE RUNCMED ON GARDS AT THE COMPLETYEN OF THE FINAL REPLICATION.

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THE INITIAL VALUES IN THE RANDOM NUMBER GENERATOR ARRAY ARE

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THE MAXIMUM SIMULATION TIME IS ****** SECONDS*

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THE INTERSHIP COMPUNICATIONS TRANSPISSION TIME IS 15.0 SECONDS.

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GAME IDENTIFICATION --- DEMONSTRATION CASE 1

DEPENSIVE UNIT INFORMATION

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| | 258.9 | 260.5 | 2,68,0 | 6.892 | 96 | 28 | 288.9 | 282.5 | 282.9 | 317.5 | 317.9 | 337.5 | 337,9 | 357.5 | 357.9 | 377.5 | 377.9 | 380.0 | , | • • • • • • • • • • • • • • • • • • • | 387.8 | | 3900 | | 397.5 | 397,5 | | 70.06 | 404 04 8 | 404.9 |
| | 29 258.9 | 29 260.5 | 97C | | | | | 31 282.5 | 31 282.9 | 31 317.5 | 31 317.9 | 31 337.5 | 31 337,9 | 31 357.5 | 31 357,9 | 31 377.5 | 31 377.9 | 31 380.0 | | 95 36 | 33 382.8 | | 30 3900 | | 30 397.5 | 30 397.5 29 397.9 | | | 29 404 55 | 30 404.9 |
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| • | r-0m. | | | י | ~ | N | | • | ю. | | ~ ∾ | ~ | c o | , NO | | • 10 | V | 6 0 | 80 | → ~ | ~ | - | • | ∞ ~ | - | ~ ~ | , , | • | - | - |
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| • | 787.2 | 709.8 | 709.8 | 705.8 | 710+8 | 729.8 | 731.8 | 729.8 | 731.8 | 766.8 | 824.1 | 824.0 | 786.8 | 8.00 | 8,908 | 797.1 | 797.2 | 86 4 9 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 | 864.2 | 806.8 826.8 | 828.8 | 806.8 826.8 | 828.8 | 834,0 | 834.1 |
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| COMEIN COMEIN TEWA | TEWA | OUTGO | | | | ABORT | ABORT | 00160 | TERA | TEWA | RELEAS | RELEAS | LEAVE | LEAVE | LOSE | | ENTER | NODE | IMPACT | | | DAMAGE | DAMAGE | DAMAGE | DAMAGE | COMEIN | <u>.</u> | DISCHN | . V | NA NA NA NA NA NA NA NA NA NA NA NA NA N | |
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| | ENTER | 16 | 0.441 | 27.56 | 1-02 | | |
| | LEAVE | • | 0.084 | 23.00 | 51.0 | | |
| | DISROR | • | 0.156 | 00.00 | 0.36 | | |
| | DISCHN | ···c | 0.120 | 00.00 | 80.00 | | |
| | OISLAN | • ~ | 0.056 | 200 | E1 00 | | |
| | COMEIN | 9 00 | 0.050 | 14.00 | | | |
| | 00T00 | | 0.00 | | | | |
| | NACC | • | 10000 | 146.80 | 40.6 | | |
| | REPAIR | • •• | 0.867 | 144 | | | |
| | DAMAGE | • | 09100 | 000 | £6.0 | | |
| | 9 | • •0 | 0.592 | - 9 · 00 · 00 · 00 · 00 · 00 · 00 · 00 · | 16.97 | | |
| | | | | | | | |
| | TOTALS | 257 | 43.149 | 167.89 | 100.00 | | |
| | MAXIMUM . | MAXIMUM CALENDAR SIZE 1565334801 IS THE CURREY | | ALENDAR SIZE Sequence | 58 | | |
| | 11782691 | 1178269188 IS THE CURRENT VALUE | NT VALUE OF THE Y | Y SEQUENCE | | | |
| H | CURRENT VALUES | | IN THE RANDOM NUMBER GENERATOR | RATOR ARRAY ARE | | | |
| • | | | 52 386467854 | | 1944454401 | 1508539226 | 16898198 |
| | 13884793 | | | | 483065510 | 1983964471 | 9128159 |
| | 679339243 | | - | 11 271921437 | 565904639 | 1953407147 | 20540581 |
| | 751995646 | | | | 434397593 | 2034814536 | 10033079 |
| | 1934870122 | | | | 1986416323 | 1766195388 | 16453951 |
| | 1565334801 | 1901690596 | 96 1941306072 | _ | 524308258 | 242395953 | 19113144 |
| | 296871904 | | | • | 1336938265 | 1914451322 | 13153601 |
| | 76930936 | 36 1304645769 | 9 1000430104 | 1802424200 | 2104832565 | 1098961909 | 7282019 |

PROMABILITY OF DETECTION AT DETECTION MINIMUM MAXIMUM AVERAGE

AVE.RNG. 838.6 734.7

PRIMARY RADAR DETECTIONS . MIN.RNG. MAX.RNG.

DEFENSE UNIT

RADAR TYPE NO. NAME

RADAR Set

BY RADAR SET

1.00

1.00

1.00

1033,4

4.064

MOCK ANSPS-29

SUMMARIES FOR REPLICATION NUMBER

| | | | PAGE 8 | | | JOE AVERAGE | 50.0 | PAGE 9 |
|---------------------------|--|------------------------------|--|----------------------------------|-----------------|--|------------|--|
| | | | | | | INTERCEPT ALTITUDE . MUM MAXIMUM AV | 50.0 | |
| <u> </u> | 7 E | 0.5 | | | | INTER MINIMUM | 20.0 | |
| | KILLS PER INTERCEPT | 0 • 500 | | | | e AVERAGE | 8,692 | |
| | TOTAL KILLS | ותות | | p=4 | | CEPT RANG | 302.7 | |
| | INTERCEPTS | ** | | ON NUMBER | | INTERCEPT GANGE MINIMUM MAXIMUM A | 228.7 | ON NUMBER |
| | FIRED | •• | | EPLICATIO | | KILLS PER Intercept | 0000 | FPLICATIO |
| | MISSILE TYPE(S) | | | SUMMARIES FOR REPLICATION NUMBER | | TOTAL KILK | • | SUMMARIES FOR REPLICATION NUMBER |
| NEL GROUP | DEFENSION OF THE CONTRACT OF T | ~ ≈ | CASE 1 | SUMMAR. | | TOTAL TO Intercepts KI | 6 0 | |
| BY GUIDANCE CHANNEL GROUP | YPE Name | DUAL SIMPLEX CUAL SIMPLEX | GAME IDENTIFICATION DEMONSTRATION CASE 1 | | BY MISSILE TYPE | TOTAL | w | GAME IDENTIFICATION DEMONSTRATION CASE |
| 65 | G.C.G. TYPE NO. NAME | ~ ~ | CATION - | | œ | 14 | MOCK TALOS | ECA TOON 1 |
| : | GUID. CHAN. | e | GAME IDENTIF | | | MISSILE TYPE NO. NAME | 1 MOCK | GAME IDENTIF |

TOTAL GOSTS IN THOUSANDS OF DOLLARS

| 3422(SUM) | | ENEMY IMPACTS UNDAMAGED COMPONENTS INTENDED EXPERIENCED INITIAL FINAL | ** | |
|---------------------------|---------------|---|----------------|--|
| 10). | | IMPACTS U Experienced | МO | |
| 1384 (SČENAHIO). | | | P C | |
| | | INTERCEPTS ACHIEVED NUMBER AVERAGE RANGE | 269.8 269.8 | |
| 800 (ORDNANSE) | | INTERC | •• | |
| 900 | | PRIMARY RADAR DETECTIONS Number Average Range | 838.6 736.7 | |
| 1258 (DAMAGE AND FAILURE) | DEFENSE UNIT | PRIMARY F NUMBER | ውው | |
| VAGE AND | 8 4 0€ | | TWO | |
| \$8 (DA) | | - | SHIP ONE | |
| 12 | | NAN | TEST S | |
| | | DEFENSE UNIT | ~ 0 | |

| | DEF. ASSEGNMENTS DEATH POSITION AT DEATH SHIP G.C. GROUP N MADE IAIN. CANDITO THE CONTROL OF THE CANDITO THE CONTROL OF THE CO |
|------------------------|--|
| | ATH POS |
| | DEF. ASSEGNMENTS DE |
| BY NONIMPACTING TARGET | PARASITES CARDIED |
| | T TGT TYPE |
| | F 2 |

SUMMARIES FOR REPLICATION NUMBER

GAME IDENTIFICATION --- DEMONSTRATION CASE 1

PAGE 11

GAME IDENTIFICATION --- DEMONSTRATION CASE 1

SUMMARIES FOR REPLICATION NUMBER

| | ING DEATH MISSILE TYPE | | PAGE 13 | | | |
|---|--|---|----------------------------------|----------------------------|--|-------------------------------|
| | ID OF UNIT INFLICTING DEATH SHIP G.C. GROUP MISSILE NO. NO. TYPE | N - N - | | | | |
| | ID OF SHIP NO. | ~ - ~ - | | | Z O | |
| | | 0000 0000 0000 | | | ABLED UNIT | |
| | POSITION AT DEATH X | 0.0 0.8 1.2 0.2 1.2 0.3 1.2 0.3 1.2 0.3 1.2 0.3 1.2 0.3 1.2 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 | м. | | THE ASSIGNED DEFENSE UNITY DAYS THE ASSIGNED DEFENSE UNITY PADABE ALINCOPES OUTO.CH.S. | 000 |
| | DEATH TIME | 383.8 410.4 789.5 | NUTBER S | | NO. OF THE AS | 000 |
| D IMPACT | DEF. ASSIGNMENTS Made Laum. CMPLTD. | ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ | SUMMARIES FOR REPLICATION NUMBER | | DEF. ASSEGNMENTS MADE LAUN. CMPLTD. | 0 0 0 0 0 0 |
| R BOR T | DEF. | N 4 N 4 | 1ES F0 | ED | DEF. | 000 |
| KILLEB P | TIME OF IMPACT | 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 | 1 SUMMAR | SITES WHICH ARE NOT KILLED | SCHED. TIME OF LAUNCH IMPACT | 4200 S |
| HICH ARE | SCHED. | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | ASTRATION CASE | HICH ARE | SCHED. | 0.00 0.00 0.00 0.00 |
| BY PARASITES WHICH ARE KILLED PRIOR TO IMPACT | SHIP ATKD. | | DEMONSTRATI | BY PARASITES W | SHIP ATKD. | |
| | 1≺PE ZAME | E E E E E E E E E E E E E E E E E E E | GAME IDENTIFICATION DEMON | | TYPE NAME | AISSILE APSSILE APSSILE |
| | 161 NO. | ~ ~ ~ ~ | IOE N. | | T07 | O O O |
| | 16 10 10 | 6 Þ Æ Ø | 6A A A | | 161 NO. | N W 4 |
| | | | | | | |

1 REPLICATIONS OF THIS GAME SITUATION, BEEN PREVIOUSLY MADE. --- SAMPLE SCENARIO ---TDHS VERSION GAME IDENTIFICATION THERE ARE TO BE

MAGNETIC TAPE FILE 2 HAS BEEN USED FOR THIS RUN.
THE FILE IDENTIFICATION IS --- SAMPLE SCENARIO SAMPLE SCENARIO

O HAVE

OF WHICH

DETAILED PREREPLICATION LISTINGS OF THE TYPE DATA WILL BE PRINTED FOR 1ST REPLICATION(S). DETAILED POSTREPLICATION SUMMARY LISTINGS WILL BE PRINTED FOR 1ST REPLICATION(S). SPECIAL DEBUGGING OUTPUTS WILL BE PRINTED FOR NO REPLICATION(S).

EVENT OCCURRENCES WILL BE PRINTED FOR ALL REPLICATION(S).

EVENT INSERTIONS AND DELETIONS WILL BE PRINTED FOR ALL REPLICATION(S).

THE EVENT MONITORING TIME INTERVAL IS FROM -660.0 TO 1000.0 SECONDS.

LAUNCH DISCHN PRELF ASSIGN DISRDR SLEEP IMPACT LEAVE WAKEUP VANISH ENTER NEWDET NOUE VICTIM MISSTK LOSE EMERGE UPDATE EVENT TYPES TO BE MONITORED ARE AS FOLLOWS-SCAN DETECT PASS PSSDET LOSE ABORT DIE TEWA DROP EMERGE TRKSUP TRACKR DROPTK SPLITK UPDATE LATESP

TRNSFR OUTGO LATEDT

RELEAS COMEIN DUD

INTCPT DISLAN IFFAIL

ΑT ON CARDS RANDOM NUMBER GENERATOR ARRAY VALUES WILL NOT BE PUNCHED THE COMPLETION OF THE FINAL REPLICATION.

X IS THE INITIAL VALUE OF THE X SEQUENCE X IS THE INITIAL VALUE OF THE Y SEQUENCE

628961741 46149533 1478422646 1644807719 1548471890 1548471890 1722131581 676625006

24938492 810564660 1819760567 699736322 1980120134 806214062 1931403913 827068390

1129150179

1294486787

P TO INITIATION 675601322 1676411406 529657843 280830942 1896072959 1798783650 WILL BE 200 RANDOM NUMBERS DISCARDED PRIOR

THE MAXIMUM SIMULATION TIME IS 1000.0 SECONDS.

THERE

THE INITIAL EVALUATION REACTION TIME IS 10.0 SECONDS.

THE THREAT EVALUATION AND WEAPON ASSIGNMENT TIME INTERVAL IS 20.0 SECONDS.

THE INTERSHIP COMMUNICATIONS TRANSMISSION TIME IS 15.0 SECONDS.

PARAMETER TRACKING

S

THE REACHABLE SET SHAPE IS CIRCULAR.
THE MAXIMUM ALLOWABLE REACHABLE SET DIMENSION IS 60 KFT.

Ŧ

WORKLOAD PER TRACKER REMUIRED TO ACTIVATE AN ADDITIONAL TRACKER IS 5 TRACKS. DEACTIVATE AN OPERATING TRACKER IS 4 TRACKS.

THE MINIMUM TIME BETWEEN ATTEMPTS TO UPDATE A TRACK IS 10 SECONDS.

THERE ARE 5 UPDATE REPORTS REQUIRED FOR ESTABLISHMENT OF A FIRM TRACK.

A POTENTIAL SPLIT TRACK MUST HAVE A SPEED WITHIN 40 PERCENT OF THE PARENT TRACK. Otherwise, it will be entered as a new detection.

TARGETS SEPARATED BY LESS THAN 1000 FEET WILL BE CLUSTERED AND WILL BE REPRESENTED BY A SINGLE TRACK SYMBOL.

THE NUMBER OF CONSECUTIVE MISSED REPORTS NECESSARY TO INITIATE DROP TRACK ACTION IS 3.

ZONE OF INTEREST BOUNDARIES FOR DET/TRK OPERATOR SEQUENCING ARE

A NEW DETECTION (OR TRACK SPLIT) MADE AT LESS THAN 240 KFT IS A LATE DETECT (OR LATE SPLIT).

9 TO 44 DEGREES. PRIMARY ZONE Secondary Zone

GAME IDENTIFICATION --- SAMPLE SCENARIO

| | | IMITS (SEC) | MAXIMUM | ~ | 13 | 13 | 10 | 1.3 |
|---|--|-------------------------|---------------|---------|---------|----------------|---------|---------|
| | | MEAN VALUE LIMITS (SEC) | MINIM | ~ | m | • | • | 4 |
| | | AUTOMATIC | OFFSET | 8 | YES | YES | YES | VF.0 |
| | | SCOPE LIMIT | (KFT) | 1536 | 1536 | 1536 | 0 | 76.0 |
| | BALL TAB ERRORS, SCOPE LIMITS AND SERVICE TIME MEAN VALUE LIMITS | BALL TAB ERROR | (*001 INCHES) | 10 | 31 | 31 | 31 | |
| | CE TIME | RADAR | | | - | - | - | _ |
| | TS AND SERVI | DEFENSIVE | LINO | - | - | | | _ |
| | SCOPE LIMI | OPERATOR | TYPE | TRK/SUP | DET/TRK | DET/TRK | DET/TRK | ACT/TOK |
| | TAB ERRORS | OPERATOR | • 0 | | | ~ | m | 4 |
| 1 | BALL | | | | | | | |

REACHABLE SET SCALE FACTORS

| SCALE | ACT0 | 2,250 | 2,030 | 1.786 | 1,520 | 1,250 |
|--------|------|-------|-------|-------|-------|-------|
| NO. OF | 0 | - | ~ | ო | 4 | ß |

RADAR OBSERVATION ERRORS

| AZIMUTH SIGMA (Mils) 1 |
|-----------------------------------|
| RANGE SIGMA (RESOLUTION CELLS) |
| RADAR NO. |

| IDENTIF | GAME IDENTIFICATION | | SAMPLE SCENARIO | NARIO | | | | | | | | | | | PAGE |
|---------------------|--|--------------------------|-----------------------|--------------|---|--|---|--|---------------------|--|--|--|----------------|---|---|
| | | | | | | DEFENSIVE UNIT INFORMATION | NI LIND | FORMATI | 70 | | | | | | |
| DEFENSIVE UNIT | NIT NAME DLG=U DDG=V DDG=W DDG=X DDG=X DLG=Z CVG=X TRACK SUFA SUFA SUFA SUFA SUFA SUFA SUFA SUFA | CENTEL DE: | R 17TRK O FIRST | X | POSITION 24 - 000 - 000 0 0 0 0 0 0 0 0 0 0 0 0 0 | 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | HEADING DEGREES 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | TE & C & C & C & C & C & C & C & C & C & | | RADDARS 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 6.C. GROUPS 17.S. 7 0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0. | skoups NO. 0 0 0 0 0 | | FIRST NO. 00000000000000000000000000000000000 | FIRST NO. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| RADAR NO. BOL | RIGHT SE | SECTOR WIDTH 360.0 | | RADAR 40. | RIGHT | RADAR Sector Width | RADAR SCAN SECTORS (CTOR RADAR (IDTH NO. | CTORS RADAR NO• | RIGHT | | WIDTH | | RADAR NO• | RIGHT BOUNDARY | SECTOR #IDTH |
| RADAR SI NO. OPI | SIM. RJ OPTION P | RADAR NO. | SIM. OPTION | RADAR NO• | | RADAR SIMULATION MODEL OPTION SELECTIONS SIM. RADAR SIM. RADAR SII OPTION NO. OPTION NO. OPT | M MODEL OPT AR SIM. | 0P110N | SELECTION RADAR NO. | SIM. SIM. | AADAR NO• | | SIM. OPTION | RADAR NO• | SIM. OPTION |

PAGE 4

INTERSHIP COMMUNICATIONS LINK STATUS DATA

DEFENSIVE UNIT INFORMATION

Out The Sates of

| | 본별 | THE I | FIN | IAL | INITIAL LINK ND I + L | | S X X | TIAL | LY IN |
|------------|----------|------------|----------|----------|-----------------------|----------|----------|------|--------|
| CEIV | ۳ | TRANSMITTI | HIH | IIN | 90 | EFE | DEFENSE | UNIT | NUMBER |
| NUMBER | - | Cu . | m | 4 | ហ | 9 | 7 | | |
| 1 | H | - | - | - | H | - | H | | |
| 2 | H | - | - | ч | H | - | . | | |
| E. | — | - | - | H | H | H | . | | |
| 4 | - | н | н | н | - | H | - | | |
| r o | - | H | - | . | H | H | - | | |
| • | - | - | - | H | - | - | - | | |
| 4 | - | - | - | - | - | - | - | | |

ALL OF THE LINKS MAY BE MUDIFIED

| 0 |
|-----------|
| SCENARI |
| SAMPLE |
| |
| ATION |
| IDENTIFIC |
| GAME |

PAGE 6

DISTANCE 1 KFT 180,000 48,000

| | | SPEED 4 | FT/SEC | 1200.0 | 1400.0 | |
|--------------------------|-------------------------|------------|---------|--------|----------|--|
| | | ALTITUDE 2 | KFT | 2.000 | •100 | |
| | | SPEEU 3 | FT/SEC | 1200•0 | 1400.0 | |
| 707 - 4820 - | | THETA 2 | DEGREES | 9.0 | 4•0 | |
| FIENSIVE UNIT INFORMATIO | | SPEED 2 | FT/SEC | 1200.0 | 1400.0 | |
| מין די | | ALTITUDE 1 | KFT | 30,100 | 1.000 | |
| | | _ | _ | 0.09 | | |
| | PTIONS | SPEED 1 | FT/SEC | 1200.0 | 1000.0 | |
| | TLE DESCRI | NO. OF | LEGS | 4 | * | |
| | WEAPON PROFILE DESCRIPT | PROFILE | NUMBER | | N | |

| GAME IDENTIFICATION SAMPLE | ICATION | | SCENARIO | | | | | | | | | ď | PAGE 7 |
|---|-----------------------|----------|--------------|--------------|-------------|----------------------------|------------|-------|----------------|-------------|-------------|---------------------------------|----------|
| | | | | ō | FFENSIVE | OFFENSIVE UNIT INFORMATION | VFORMAT | r10V | | | | | |
| MASTER FLIGHT PATH X X Y -564.40 806. | Т РАТН У 806.05 | 30.00 | T -360.00 | X -412,98 | Y 589.79 | | 2 30•06 | ٠.00 | × 344.15 | 7 491.49 | 00°0£ | r 163.64 | |
| | | | | | | | | | | | | | |
| TARGETS | TYDE | | i i | | 4 | A A C | A S I | T E S | SACAMETERS | | AIRCRAFT DI | AIRCRAFT DISPLACEMENTS FROM MFP | FROM MFP |
| NO. | NAME | lui | GROUP | ACT. | | | | NODE | NODE DISP. INT | | AND PAILOR | AND PAILONE PROBABILITES (* X X | 155 (*) |
| | | | 1 | | | | | ! | | , | 75.712 | -108,128 | 2.000 |
| · • | | | ~ | | | | | | | | | -6.007 | 00000 |
| 3 | • | | 0 | , | | | | | | | • 205 | .143 | 00000 |
| 4 | AS | Σ | 0 | _ | ~ | 0 | _ | ď | 0 | | *000*0 | *000*0 | *000*0 |
| S S | ĄSI | Σ | 0 | ~ | 7 | 0 | - | N | - | | *000*0 | *000*0 | *000*0 |
| . 6 | | | 0 | | | | | | | | -4.4]] | 5,864 | 00000 |
| 7 | ASI | Σ | 0 | 7 | ~ | 0 | | N | 10 2 | | *000*0 | 0.000 | *000*0 |
| 8 | ASA | Σ | 0 | 7 | ۷ | 0 | - | N | 70 2 | | *000*0 | *000*0 | *000*0 |
| 6 | | | 6 | | | | | | | | -7.798 | 12,444 | 00000 |
| 10 2 | ASI | Σ | 0 | ^ | _ | ¢ | - | N | 20 | | *000*0 | 1.000 | *000*0 |
| 11 2 | ASI | . | 6 | | 7 | 0 | _ | N | 80 | | *000*0 | *000*0 | *000*0 |
| 12 1 | | | 0 | | | | | | | • | -13,233 | 17,591 | 00000 |
| 13 | ASI | Σ | 0 | • | ^ | • | _ | ~ | 30 5 | | *000*0 | *000*0 | *000*0 |
| 2 +1 | ASi | I | 0 | _ | 7 | 0 | _ | N | 90 | | *000*0 | *000*0 | *000*0 |
| . 15 | | | 0 | | | | | | | • | -15.801 | 24.745 | 0.00 |
| 16 2 | ASI | ¥ | 0 | 7 | 7 | 0 | _ | ń | 5 04 | | 1.000* | *000*0 | 00000 |
| 17 2 | AS | Σ. | 0 | 7 | 7 | 0 | - | N | 100 2 | | *000.0 | *000*0 | *000*0 |
| 18 1 | | | 0 | | | | | | | • | -22,055 | 29,319 | 00000 |
| 19 | ASI | Σ | 0 | _ | ^ | 0 | -4 | ~ | 50 | | *000*0 | *000*0 | *000*0 |
| 20. | ASI | . | 0 | 7 | _ | 0 | - | N | 110 2 | | *000*0 | .000.0 | *000*0 |

| TION |
|-----------|
| NFORMA |
| UNIT I |
| OFFENSIVE |
| |

| PAGE 10 | | | AIRCRAFT DISPLACEMENTS FROM MFP AND FAILURE PROBABILITIES (*) 0,000 |
|-------------------------------------|----------------------------|---|--|
| | | ۰ | DISPLACEME URE PROBABI O-000 |
| | | 2 | AIRCRAFT AND FAIL X |
| | | > | |
| | | × | P A R A S I T E S GUID. WPN. LAUNCH PARAMETERS REG. PRF. NODE DISP. INT. |
| • | ATION | -300 • 00 | T E S LAUNCH NODE |
| | T INFORM | 25.00 | A A S I |
| | OFFENSIVE UNIT INFORMATION | Y 886•33 | P / SHIP ATKD. GUIC ACT. INT. REQ. |
| | 96 | X 156•28 | SHIP ACT. |
| CENARIO | | T Z Y Z T T T T T T T T T T T T T T T T | ECM GROUP |
| SAMPLES | | 2 25 • 00 | |
| GAME IDENTIFICATION SAMPLE SCENARIO | | ER FLIGHT PATH X Y 208.38 1181.77 | ET TYPE NAME |
| NTIF | | L 16H1 | TARGET NO. |
| GAME IDE | | MASTER FLIGHT PATH X 208.38 1181. | TARGETS TGT 1 NO. N |
| | | | |

| | 0.00 | -660.0 | -646.9 | -649.9 | -625.9 | -632.2 | -620.2 | -625.9 | -623,3 | -620.6 | -617.9 | 9 | 2 0 0 0 | -617.9 -613.0 | | -610.4 | -607.7 | -596.2 | -605.0 | -602.4 | -599.7 | -597.0 | 4.465- | | 5.84.2 | -594.4 -585.5 | | -582.8 | -572.2 | -580.2 | -577.5 | -574.8 | -572.2 |
|-----------------------|------------|------------|------------|------------------|------------|--|-----------|-----------|-------------|--------|-------------|------------|------------|------------------|------------------|------------|------------|-----------|------------------|--------|--------|------------|------------|------------|------------|------------------|--------------------------|------------|------------|--------------|-------------|--------|------------|
| | 1.1 | 18 | 18 | 138 | 5 0 | ÷. | 19 | 19 | 19 | 19 | 19 | - | f | 50 2 | | 16 | 19 | 16 | 19 | 19 | 19 | 19 | 19 | | <u> </u> | 5 2 | | 13 | 16 | 19 | 19 | 19 | 19 |
| | 74 | 4 | - | | - | - | ~ | - | - | - | - | - | • . | | | ~ | - | | ~ | - | - | - | - | - | . | | , | - | - | - | - | - | - |
| | 1.4 | - | - | | - | - | - | - | - | | | - | • | | | | - | - | 1 | ~ | - | - | - | | | | | - | - | - | 7 | - | - |
| of all coll to all to | מיטידיטיי | ENTER | TRKSUP | NEWDET TRKSUP | WAKEUP | TRKSUP | TRKSUP | TRACKR | TRACKR | TRACKR | TRACKR | TEKSIE | | UPDATE | | TRACKR | TRACKR | TRKSUP | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | | 708 XX | UPDATE | | TRACKR | TRKSUP | TRACKR | TRACKR | TRACKR | TRACKR |
| SOFTALDE | - | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | TASEDT | | INSERT | | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT | | INSER | INSERT | | INSERT | INSERT | INSERT | INSERT | INSERT | INSERT |
| יט פעני. | 11:719 | 11.742 | 11.751 | | 11.820 | 620.11 | 100011 | 5 0 0 1 1 | 11.651 | 19911 | 11.872 | 11.882 | 11.891 | | 11.955 | 11.969 | 11.978 | 889-11 | 900-11 | 000.01 | | 12.018 | 12.028 | 12.038 | 12.048 | | 12•109 12•112 | 12,123 | 12,132 | 12.142 | 12,153 | 267.21 | 74 1 1 2 2 |
| 7 1 145 | | -660.0 | 6.649- | • | 6*6*9= | 20440 | 3 4 4 6 7 | 6000 | 6629 | -66363 | 9.029 | -620.2 | -617.9 | | -617.9 -613.0 | -610.4 | -608.2 | | 900 | | 100 | -2669-1 | -297.0 | -5969- | -594.4 | | -594.4 -585.5 | -584.2 | -582,8 | 5 0 8 Z | 7 6 | | 20/4-8 |
| GNC | 7 | 4.7 | - | | - | • - | • - | ٠. | ٠ . | → . | → | - | - | | | - | | - | • - | • - | • . | - | | - | - | | | - | ~ | - | • - | • - | - |
| 151 | 74 | - | - | | ٦. | ٠. | ٠. | | ٠. | | - | - | - | | | - | - | - | • - | | • . | - | - | | 7 | | | - | - | - | ٠ - | • - | - |
| 7 V D F | NODE | ENTER | TRKSUP | | NEWDET | ייטע אמן אמן אמן אמן אמן אמן אמן אמן אמן אמן | | | A ACTA | K 40 4 | TAPONE N | TRKSUP | TRACKR | | UPDATE TRACKR | TRACKR | TRKSUP | TRACKR | T A A A A | | | TRACKE | HACKE | TRKSUP | TRACKR | | UPDATE TRACKR | TRKSUP | TRACKR | TRACKB | | | ۲ |
| 17.67.6 | occurrence | OCCURRENCE | OCCURRENCE | | OCCURRENCE | | | | מכניסאבוגנב | | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | CCURRENCE | E CALEBRATION OF | | | OCCURRENCE | OCCUMMENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | FONTERGITOTO | TO NEGOTION | | טטטטאביינב |
| CFO. | | N | m | | 4 11 | | • • | ٠ , | 20 (| • | 10 | = | 12 | | 13 | 15 | 16 | | . <u>«</u> | 2 2 | : : | 20 | 21 | 22 | 23 | | 2.5 4.5 | 56 | 27 | œ | , o | | 2 |

| | -560.2 | 5.695- | 1569.5 566.5 | | 100319 | 10110 10101 | 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 | , n | 10001 | 7 0 1 | D 0 | 60/40 | -536,2 | -547.9 | • | 1540.1 | +537.4 | *534 · 8 | -524.2 | -532.1 | -529.4 | *526.8 | 1.470 | 2.216. | -521.4 | -520 . 1 | -517.4 | -514.8 | -512-1 | | 4 do 4 | +*605- |
|---------------|------------------|--------|-----------------|--------------------------------|---|----------------------------|---|---------------|---|---------------|---------------|---------------|---------------|----------|--------------------------------|---------------|---------------|---------------|---------------|-------------------|---------------|---------------|---------------------------------------|---------------|---------------|--------------------------------|--------|---------------|---------------|---------------|--|---------------|
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| #572,2 12,172 | . ~ | | -569.5 12.191 | -569.5 12.253 -566.6 12.257 | -563,9 12,266 | •561 _• 2 12•276 | -560.2 12.285 | -558,6 12,296 | -555,9 12,306 | -553,2 12,316 | -550.6 12.326 | -548,2 12,336 | -547.9 12.345 | | -547.9 12.407 -542.8 12.411 | -540,1 12,421 | -537.4 12.431 | -536,2 12,440 | -534.8 12.449 | -532.1 12.460 | -529.4 12.470 | *526.8 12.480 | -524.2 12.489 | -524.1 12.498 | -521.4 12.509 | -521.4 12.570 -620 1 12.574 | | £8C.2[4./1C- | -514,8 12,594 | -512,2 12,604 | -512,1 12,615 | -509.4 12.624 |
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| 437.4 | 4.55.4 | -433.2 | -430.6 | -427.9 | -416.2 | -425.2 | 9 9 9 9 | -617.2 | 4.4.4 | 404 | 414.6 | 6,704 | - F04- | -402.6 | -392,2 | 6*666- | -397.3 | -394.6 | -391.9 | -380.2 | •389•3 | -389.3 | | 2.485 | - 381.6 | -378.9 | -368.2 | -376.2 | -373.6 | -370.9 |
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| 13,103 | 13,164 | 13.177 | 13.188 | 13.198 | 13.207 | 13.216 | 13.228 | 13,238 | 13.247 | 13,257 | 13,267 | 13,330 | 13,344 | 13,353 | 13,364 | 13,373 | 13,383 | 13.393 | 13.404 | 13.413 | 13.423 | 1 | 13.494 | 13.508 | 13,517 | A C P . F . | | 156.61 | 130047 | 100001 |
| -437.4 13.103 | -437.4 13.164 -435.9 13.168 | • | → → | • - | | -425.2 13.216 | •422.6 13.228 | -419.9 13.238 | -417.2 13.247 | -416.2 13.257 | -414.6 13.267 | -414.6 13.330 -410.6 13.334 | -407.9 13.344 | •405,3 13,353 | -404.2 13.364 | -402.6 13.373 | - | - | - | - | *391.9 13.423 | | -386.9 13.494 | -384.2 13.508 | -381.6 13.517 | | | | |) CC + CT C + CT CT CT CT CT |
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| | • | -356.2 | -365,6 | -365.6 -361.9 | -359.2 | 230.0 | • | 230.0 | 230.0 | | 230.0 | | 230.0 | | 230.0 | | 230.0 | | 360.0 | | .360.0 | • | -360.0 | 0.096- | · ! | 0.096- | 0 | -360.0 | • |
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| -370.9 | -368.2 | -368,2 | -365,6 | ın. | | 3000 | -360.0 | 360.0 | 0.000 | -360.0 | | -360.0 | • | -360.0 -360.0 | | -360.0 -360.0 | | -360.0 -360.0 | | -360.0 -360.0 | -360.0 | -360.0 | -360.0 | | -360.0 -360.0 | | -360.0 -360.0 | 0 046 | 360 |
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| 130 | 131 | 132 | 133 | | | 8 | 137 | 139 | | 141 | | 143 | | 145 | | 147 | | 150 | | 151 | | 154 | 155 | | 157 158 | | 159 | 151 | 162 |

| -360.0 | -360.0 | -356.6 | -353.9 | -344.2 | -351.2 | -348.6 | 10 | | -332,2 | -343.2 | | 336.0 | -333,3 | -330.6 | -335.2 -331.5 | | -329.7 | 6 | -320.1 | -328.6 | -328.6 -326.4 | | - 325 . 3 | 1326.6 | | -322.6 | -324.0 -321.0 | 6 | 0.025 |
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| 14.060 14.065 | 14.088 14.093 | 14.103 | 14.112 | 14.122 | 14.132 | 14.142 | 14.152 | 14.162 | 14.172 | 14.40 | 14.407 | 14.418 | 14.427 | 14.437 | 277.41 | 14.467 | 14.494 | 14.498 | 14.511 | , c | 14634 | 14.569 | 14.584 | | 14.618 | 14.635 | | 14.661 | 14.679 |
| -360.0 14.06 -360.0 14.06 | -360.0 14.08 -359.2 14.09 | -356.6 14.10 | -356.2 14.113 | -353.9 14.123 | -351.2 14.13 | -348.6 14.14 | -345.9 14.15 | -344,2 14,15 | -343.2 14.17 | • | -338.6 14.407 | -336.0 14.41E | -333,3 14.427 | -332,2 14,437 | | -331.5 14.467 | ·- | 4330.6 14.498 | -329,7 14,51] | | -328.6 14.541 | -328.6 14.569 -328.0 14.573 | -326,6 14,58 | | -325.6 14.618 -325.3 14.622 | -324,0 14,635 | | -324.0 14.661 -322.6 14.665 | -321.0 14.679 |
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| \$ 0 ~ | | ત્ર → | | o- → | | 27 | ı | - | - | - | = | | • | 75 | , | ტ, | - | - | - | - | - | ~ | 47 | • | - | - | + | ın - | • | | | |
| ,t , | • | | | | | | • | - | - | - | | • • | • | | • | - | | | | ~ | N | ~ | • 4 | ; | N | - | N N | ⊶, | - | 901 | - | |
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| | 14.705 | | 14.962 | | 14.993 | | 15.024 | 15.043 |) (| 00000 | 15.072 | | 15.105 | | 15.136 | , | 15.406 | 15.419 | 16.4.6 | CC+ CT | 544061 | 15.460 | 15•475 | 15.485 | 15.507 | 15.524 | 15.582 | 990 | 15.642 | 16.667 | | 15.666 15.673 |
| | -321.0 | | -320.0 -318,8 | | -318.8 -318.2 | • | -318,2 -315,1 | 7,015 | | 2040 | -307.4 | | -307.4 | | -307.2 | | -307.1 | -303.9 | 4 606- | 0.000 | 9.206 | -301.2 | -300.0 | -300.0 | -298.5 | -297.3 | -297.3 | _ | -295,9 | 7 286 | | -282. -285.0 |
| | ∞ | | ~ ~ | | Φ ¬ | | 91 | - | • • | • | - | | 17 | | 12 | • | e - | | ٠ - | ٠. | - | - | +1 | 4 1 | - | | 4- | • | ıs ⊶ | - | • | |
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| ۔ ہ | - | | | ٠. | . | • | - | ۲ | | 9 E | ; - -1. | | ~ ¬ | | - | | → | - | - | . | - | 6- | | 0. T | | . | - | - | ~ | - | 7 | ٦, | |
| ผพ | 4 | • < | , , | → (| N | - | - | 2 0 | i | α | ~ | | 4 | (| N | 4 | ~ | - | N | - | , i | ~ ~ | | | | . | • | N | - - , | 4 | N | - | |
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| 9 | 4.883.4 | -283.4 | -277.5 | -275.0 | -274.8 | -273.6 | | -272.3 | -272.3 | | | -272.1 -272.1 -271.4 | • | -271.4 | -266.5 | -265.5 | | -264.8 | -262.8 | -262,2 | -261.6 | -260.2 | -260,2 | | -259.5 -254.8 | -254.5 | -253.0 | -252,1 | a 1961 | 0 10 10 | £ • 0 ¢ 2 • | -246.6 | -249,5 |
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| ć | V 4 | 4 | - | 8 | - | | | N | ~ - | | | 00 ⊶ 4 | • | 4 (J | . ❖ | ۰ م | J . | - | 7 | 7 | _ | ∾ . | ~ | | | 4 | ۸. | - | • | • '(| N | - | - |
| | WAKEUP | TRACKR | TRACKR | TRACKR | TRACKR | TRKSUP | | TRACKR | UPDATE | | | SPLITK UPDATE TRACKR | • | UPDATE TRACKR | TRACKR | TRACKR | W | TRACKR | TRACKR | TRACKR | TRKSUP | TRACKR | UPDATE | | UPDATE | TRACKR | TRACKR | TRACKR | 9 | | TRACKE | TRKSUP | TRACKR |
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| | 230 | 231 | 232 | 233 | 234 | | | 236 | 237 | | | 239 240 | | 242 | 244 | K = 3 | | 946 | 247 | 248 | 549 | 250 | 251 | | 253 254 | | 256 | 757 | | 228 | 526 | 260 | 261 |
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| -246.8 | -249.1 -241.8 | 247 | • | -246.8 | 246.8 | -234.4 | | | | -539.2 | -238.0 | 236.6 | 1 | 46354 | -225.6 | -233.8 | -235.4 -228.0 | | -631.7 | 231 | -229.1 | -228.5 | -226.4 | -225.8 | - 225 . 3 | -223.7 | -223.2 | -213.6 | -225.3 | | -211.5 | -223.2 |
|-------------|------------------|--------------|------------------|-------------------|--------|--------|------------|------------|------------|--------|------------|---|------------|------------|------------|--------|------------------|------------|------------|------------|------------|------------|-------------|------------|-------------------------|------------|------------|------------|------------|------------------|------------|------------|
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| 16.934 | 900 | 16,991 | 17.242 | | | | 17.346 | 17.354 | 17.358 | . ! | 1/03/4 | 17.390 | 17.402 | 17.418 | 17.428 | 17.438 | - | 17.700 | 17.722 | 17.734 | 17.751 | 17.761 | 17.779 | 17.790 | 17.807 | 17.825 | 17.836 | 17.845 | | 17.911 17.915 | 17.975 | 17,979 |
| 1.040-1 | 240 | 247.6 | -247.6 | | : | | -246.8 | -246.8 | -246.8 | | 7.0.2- | -539,2 | -238.0 | -237.6 | -236.5 | | | -235,4 | -233,8 | -231.7 | -231,2 | -229.1 | -228,5 | -228.0 | -226.4 | -225.8 | -225.6 | -225.3 | | -225.3 -223.7 | -223,7 | -223,2 |
| - | • 0 | v - | 11 | | | | 16 | 14 | 15 | | - | - | - | - | - | - | • | ო ⊶ | - | | - | | - | - | - | - | | - | • | 4- | ß | ~ |
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| TOTO BRENCE | | OCCURRENCE | OCCURRENCE | | | | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE |
| 24.2 | 202 | 264 | 265 266 | | | | 267 | 569 | 270 | | 272 | 273 | 274 | 275 | 276 | 77.6 | - V | 278 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | | 290 | 292 | 293 |

| | -218.1 | -215.4 | -213.5 | -2017 | 9.010 | 0.01 | 211.5 | | -204.7 | -207.4 | -204.8 | -202,3 | -202.1 | -202-0 | 4199.6 | -199.3 | -189.6 | -199.6 | 199.4 | 199.3 | | -188.3 | -158.0 | -177.6 | -186.4 | -188.3 |
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| | 4 | 4 | NI 4 | , | ۰ ، | u < | | • | N N | 4 | 4 | 7 | 4 | Ν - | - 4 | ٠ ، | | | 4 4 | · ~ ~ | • • | - | N | | 4 | |
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| 18•238 18•241 | 18,252 | 18.263 | 18,281 | 18•291 | 8.301 | 18.319 | 086.81 | 8.390 | 8.658 | 1 0 | 2 | 8.701 | 8.711 | 18.728 | 18.746 | 18.757 | •774 | 8.784 | 853 | 18.910 | 18.976 | 866*81 | 9.015 | 19.033 | 19.043 | 19+354 |
| -223,2 -220,8 | _ | | | | | | | | Ä. | 4 - | 9 6 | | 8 | 18 | 18 | 18 | 18 | 18 | 18 | 8 8 | 18 | 18 | 19 | 6 | 5 | ă |
| 122 | -218,1 | -216.2 | -215,4 | -213.6 | *213,5 | -212.8 | -211,5 | -211.5 -210.8 | *210.8 | | | ٠ ٦ | - | -202,3 18 | -202-1 18 | -202.0 18 | an . | *199,6 18 | மையை | -199,4 18 -199,3 18 | -199,3 18 -191,8 18 | | *190*6 19 | -189,6 19 | -189,1 19 | -188,3 |
| 2 = 22 | 1 -218. | 1 -216,2 | 1 -215,4 | 1 -213.6 | 1 *213,5 | 1 -212.8 | 1 -211.5 | | | 4 4 4 6 6 7 | 1 00.00 | -204.8 | - | _ | | | 18 | - | 8 4 | - m | m m | 6 | - | | | * |
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| UPDATE 4 2 =22 TRACKR 4 1 =22 | - | → | 1 -215 | 7 | - | - | 1 -211 | 6 -211.5 1 -210.8 | 13 *210.8 | 1 2001 | 1 12004.0 | 4 1 -204.8 1 | 2 1 -204.7 1 | 1 -202,3 | 1 -202-1 | 1 -202.0 | 1 -201.6 18 | 1 =199,6 | 7 =199.6 18 | 2 -199.4 1 -199.3 | 8 *199,3 1 *191,8 | 1 -190.9 | 1 -190.6 | 1 -189.6 | 1 -189.1 | 1 -188,3 |
| 4 4 | 4 | 5 | 4 1 -215 | 1 | 5 1 | 4 | 1 1 -211 | 1 6 -211.5 1 2 1 -210.8 1 | 2 13 *210.8 | | TRACKR 1 1 2005.0 | TRACKR 4 1 -204.8 1 | 2 1 -204.7 1 | 1 1 -202,3 | 4 1 -202.1 | 2 1 -202.0 | 1 -1 -201.618 | 1 1 *199,6 1 | 1 7 =199.6 18 4 1 =199.4 18 | 4 2 = 199.4 1 2 1 = 199.3 1 | 2 8 *1999,3 4 1 *191.8 | 1 1 -190.9 | 2 1 *190,6 1 | 1 1 -189,6 | RACKR 4 1 -189.1 | 1 1 1 1 188,3 |

| | -188.0 | -180.7 | | -183.8 | -181.1 | -178.4 | -178.1 | | 175.8 | •175.4 | -165.6 | -177.1 | | -175.8 | | -175.4 | 0.007 | -169.2 | -166.5 | -165.9 | -164.2 | -163.9 | -163.2 | 2001 | 0.5cT | -164.2 | ; | -161.2 | -163.2 | I | -158.5 | -155,9 | -155.0 | -153.2 | -152.4 | |
|-------------|------------|--------|------------------|----------|--------|------------|------------|------------|------------|-----------|--|--------|------------------|--------|------------|--------|---------------------------------------|--------|---------------------------------------|------------|------------|------------|------------|------------|------------|------------------|--------------------------|------------|--------|------------------|--------------|--------|------------|------------|------------|------------|
| | 80 | 52 | | 20 | 20 | 20 | 20 | ì | Ş | 20 | 20 | 20 | | 202 | 1 | 20 | 3 | 20 | 8 | 20 | 20 | 20 | i | วี ถึ | Ñ | 20 | i | Ñ | 202 | l I | 20 | 20 | 20 | 20 | . 2 | |
| | • | - | | ~ | - | - | 7 | • - | - | → | - | 91 | | 24 ⊶ | | 15 | • | - | - | ~ | - | ٦ | - | • - | -1 | * - | • | - | =- | | - | - | ~ | - | - | |
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| 19.318 | 19.322 | | 19,391 | 19.405 | | 174.61 | 19.427 | 19.444 | 19.456 | 19.473 | 204.01 | | 19.550 | | 19.812 | | 19.877 | 200001 | 760067 | 19•903 | 19.920 | 19.938 | 19.949 | 19.967 | 19.976 | | 20.041 | 20.057 | | 20.319 | 20.333 | | 449.00 | 20.362 | 20.372 | 20•389 |
| . A | -188.0 | | -188.0 -186.4 | 8. B. B. | | 1.61.61 | -180.7 | -178.4 | -178,1 | -177.6 | 177 | • | -177.1 | · - | -175.8 | • | +175.4 | | 2040 | -168.5 | -166.8 | -166.5 | -165.9 | -165,6 | -164.2 | | -164.2 -163.9 | -163.2 | | -163.2 | 58.5 | | 1.761. | -155,9 | -155.0 | -154.6 |
| 9 | - | | о ¬ | _ | | - | ~ | → | - | - | | • | 16 | , | ~ | • | 15 | • - | • | → | - | - | - | - | - | | * - | ~ | • | 17 | _ | | - | ~ | ~ | - |
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| PONTROLLOCO | OCCURRENCE | | OCCURRENCE | SUNTAGE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | CCHRRENCE | STATE OF THE STATE | 700000 | OCCURRENCE | : | OCCURRENCE | | OCCURRENCE | | OCCORRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | | OCCURRENCE | E CARRETO CO | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE |
| | 328 | | 329 330 | | ; | 332 | 333 | 334 | 335 | 336 | | 55 | 338 | | 340 | | 342 | | * * * * * * * * * * * * * * * * * * * | 345 | 346 | 347 | 348 | 349 | 350 | } | 351 | 25 | } | 354 354 | | 2 | 357 | 358 | 329 | 360 |

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| -151.9 | -141.6 | -153.2 -149.5 | -152.4 | *148.3 | -151.9 | , | -146.8 | -145.6 | -144.2 | -143.0 | -141.6 | -141.5 | -140.3 | -129.6 | -138.9 | -138.8 | -140.3 | | -138.9 -130.1 | -138.8 | -131.0 | -128.4 | -127.4 | -117.6 | -125.7 | -127.4 -121.8 | | 1.631. | -123.0 | -120.5 | |
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| 20.408 | 20.418 | 20.478 | 20.482 | 20.547 | | 20.613 | 20.636 | 20.653 | 20.664 | 20.681 | 50 • 699 | 20.709 | 20.727 | 20.737 | 20.754 | 20.764 | | 21.028 | 21 • 095 | 21.099 | 21.157 | 21.172 | 21.190 | 21.200 | 012.15 | | 21.474 | 21.498 | 21.508 | 21,526 | |
| -153,6 | -153,2 | =153.2 | 152.4 | -152.4 | | -151.9 -149.5 | -148,3 | -146.8 | -145.6 | -144.2 | -144.2 | -143.0 | -141.6 | -141.6 | -141.5 | 140.3 | | -140.3 -138.9 | •138°9 | •138°B | -138.8 -131.0 | -130.1 | -129.6 | -128.4 | -127.4 | • | -127.4 -125.8 | -125.7 | -123,1 | -123.0 | |
| | | ٨ | ı ~ | 12 | | ო ⊶ | - | - | - | ~ | ~ | - | - | - | - | - | • | 4 ~ | v | ~ | 'N - | | - | | | • | 9 | | - | - | |
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| 361 | 362 | | 364 | 365 366 | | 367 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 3 3-3 | 9 8 | | 379 380 | 381 | | 88. 48. | | 386 | 387 | 88 | 8 | 389 | 391 | 392 | . 393 | |

| 7 · 26 | 6 | -92.2 | | 0.18 | -80.5 | 9.69- | -81.0 | | -80.5 | | | -72.2 | -69.5 | -67.7 | -57.6 | -66.8 | -67.7 | | -66.8 | ; | 1.40 | -61.4 | -61.1 | -58.7 | -58.4 | -57.7 | -56.1 | 55.7 | -55.0 | 8.50 8.00 | -56.1 -46.9 |
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| 27 | • | ~ v | | | - | - | e9 | | 51 - | | → . | - | - | - | ~ | 7 | =- | : | . → | • | • | - | - | - | - | - | - | - | | - | 5 - |
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| UPDATE | r 2 | UPDATE | | TRACKE | TRACKR | TRKSUP | UPDATE | | UPDATE | | TRACKR | TRACKR | TRACKR | TRACKR | TRKSUP | TRACKR | UPDATE | | TRACKR | | K A C C K | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRKSUP | UPDATE |
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| 22•628 22•632 | 22.703 | | 22.761 22.765 | 22.785 | 22.802 | 22.812 | 3 70 4 3 3 | 23.075 | | 23.146 | 23.169 | 23,187 | 23,205 | 23.223 | 23,233 | | 23.250 | 23.514 23.518 | | 23.580 23.584 | 23,598 | 23.610 | 23,627 | 23.640 | 23.657 | 23.675 | | 2000 | 23.704 | 23,722 | 23.732 |
| -92.8 | -92.7 | | -92.2 | -83.2 | -81.6 | | • | -81.0 | | -80.5 | -74.8 | -72.2 | -70.4 | 4 | 69.5 | . ! | -67.7 | -67.7 | | -66.8 -66.7 | -64.1 | -63.7 | -61.4 | -61.1 | 6.00 |) d | 0 0 | 000 | -57.7 | -57.6 | -56.1 |
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| 51.4 |) • TC | 51.7 | 51.7 | 52.5 | | 52.5 55.1 | 57.7 | | • | 61.8 | 61.8 | 61.8 | 61.9 | 62.4 | 63.1 | 63.1 | 7*60 | 63.2 | 5 5 6 | 63.8 68.6 | 70.2 | 71.0 | | • | 71.0 | 71.2 | 72.8 | 73.9 | | | 75° | 75.5 |
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| 585 | | 587 | 588 589 | 9 | | 591 592 | | 5 | 5.00 4.00 | 595 | 296 | | 598 | 669 | 909 | 601 | 209 | 603 | | 605 | 607 | 4 | | 609 | 610 611 | 612 | 613 | 414 | | 0 10 | 616 | 617 618 |

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| 29.877 | 29.682 | 004.62 | 29,908 | 29•930 29•935 | 29.955 | 29.974 | 26.62 | 30.00 | 30 • 085 | 30•089 | 30.458 | | 30.544 30.548 | 30.556 | | 30.578 30.583 | 30.604 | 30.622 | 30.638 | 30.648 | | 30.755 | | 30.850 30.855 | 30.863 |))) | 30.885 | 30.911 | |
| 76.6 | 80°2 | 0 • 18 | 81.0 | 81.0 81.1 | 83.2 | 85.9 | 96.4 | 97.4 | 87.4 | 88 80 | 88 88 5 | | 88.5 90.3 | 90.3 | | 90.3 | 96.1 | 98.4 | 98.4 | 98.8 | | 8 8 6 | 9 | 100.2 | 100.6 | ; ; ; | 100.6 | 101.0 | |
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| | 111.6 | 113.0 | 122,4 | 111.6 | | 111.8 | 111.9 | | 379.4 | 113.0 | 118.5 | : | 116.4 | 119.0 | 121.2 | 121.7 | 122.1 | 123.8 | 124.4 | 124.8 | 134.4 | 123.8 | | 124.4 | | 124.8 | | 135.7 | 146.4 | 135.7 | • • • | 140.9 |
|------------|------------|------------|------------|------------------|--------------------------|------------|---------------|--|------------|------------------|---|------------|------------|------------|------------|------------|------------|------------|--|------------|-------------------|-------------|--------------------------|------------------|--------------------------|--------|--------------------------|-----------|--------------|------------|--------------------------|------------|
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| 101.0 | 110.4 | 110.4 | 111.6 | | 111.6 | 111,8 | | 111.8 | 113,0 | | 113.0 | 113.7 | 116.4 | 118,5 | 119.0 | 119.5 | 121.2 | 121.7 | 122.1 | 122.4 | | 163,68 | 123.8 | • | 124.4 | | 124.8 133.0 | 134.4 | 135.7 | • | 135,7 138,3 | 138,8 |
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| 34.131 | 34.141 | 34.156 34.163 | 34.172 | 34.199 | 34,219 | 34,239 | 34.260 | | 34.6/4 | 34.593 | | 34.701 34.706 | | 34.799 | | 34.814 | | 34,633 | | 34.853 | | 34.878 | 34.898 | 34+918 | 34.929 | | 35,239 35,243 | | 35,322 35,326 | 1 | 35.396 |
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| 197.3 | 191.4 | 193.2 | 194.0 | 195.9 | 196.7 | 195.9 | | 196.7 208.1 | | 209.3 | 200.0 | 202.7 | 205.3 | 208.0 | 208.8 | 9 | 214.1 | 208.1 | | 208.8 | ć | 2,412 | | 0 · 0 · 1 | 216.8 | 219.2 | 219.4 | 219.5 | 219.2 | 219.4 | 231.6 |
| *2 | 23 | 23 | 23 | 23 | 23 | 24 | | 23 | | Ś | 23 | 23 | 23 | 23 | 23 | ; ; | S & | 57 E. 4 | | 23 | ŗ | 3 8 | 3 6 | 3 | 23 | 23 | 53 | 23 | 23 | 23 | 24 |
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| 185.3 | 188.7 | 190.5 | 191.4 | 193,2 | 194.0 | 195.9 | 195.9 | | 196.7 | 107 3 | ? | 200•0 | 202.7 | 205.3 | 206.1 | 208.0 | | 208.0 208.1 | 208.1 | | 208.8 | 213.9 | 214.1 | 214.2 | 216.5 | 9.415 | | 216.8 | 219.2 | 219.2 219.4 | |
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| OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | | סככחאובייכב | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | |
| 754 | 756 | 757 | 758 | 759 | 160 | 761 | 762 | 3 | 764 | | 99) | 767 | 768 | 769 | 4 770 | 177 | | 772 | 774 | - | 776 777 | 778 | 779 | 780 | 187 | | 787 | 783 | 784 | 785 786 | |

| | 219.5 219.5 | , | 233,3 | 229.5 | 31 | O. | • | 230.7 291.1 393.6 | . 3 | 391.6 | 310.2 | | 320•2 393•6 | 270.9 331.0 393.6 | 280.1 340.0 | 393.6 | 231.6 | 3.0 | 3 6 | 243.6 | 245.3 | 241.3 | 242.4 | 240.2 | 240.3 |
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| 36. | 3 | 36. | 36.8 | 36. | 36 | 36• | 36. | | 36• | 37. | , | 37. | 37. | | 37. | 37. | , | 37. | 37. | 37 | , | | 37. | 37. | 37. |
| 219,4 36, | | 219.5 36. 219.5 36. 221.3 36. | | | | 230.0 36. | 230.0 36. | | 230.0 36. | 230.0 | , | 230.0 37. | 230.0 37. | | 230.0 37. | 230.7 37. | 5 | 231.6 37. 231.9 37. | 231.9 37. 232.1 37. | 232+1 37 | , , | 5 6 | 39,7 37 | 40.2 37 | 240,2 37. |
| | • | | | 29.5 | | 6 | 36 | | 30.0 | 7.5 | | 30.0 | 76 0, | | 30.0 | . 16.6 | | 31.6 37 31.9 37 | 31.9 37 32.1 37 | 37 | 20000 | | 239.7 37 | 240,2 37 | 37 |
| 219.4 | | 219.5 219.5 221.3 | 1 226.8 | 259.2 | 1 229,5 | 230.0 | 230.0 36 | | 5 230.0 | 75 0.056 | | 230.0 37 | 230.0 37 | | 230.0 37 | 230.7 37 | | 4 231.6 37 1 231.9 37 | 231.9 37 232.1 37 | 2 232+1 37 | 1 23063 37 | C 00000 1 | 1 239,7 37 | 25 240.2 37 | 240,2 37 |
| 23 219.4 | | 24 219 ₆ 5 22 219 ₆ 5 1 221 ₉ 3 | 1 1 226,8 | 1 229,2 | 1 229,5 | 21 230.0 3 | 22 230,0 36 | | 25 230.0 | 7£ 0-0FG 8G | | 31 230.0 37 | 34 230.0 37 | | 37 230•0 37 | 22 230.7 37 | | 14 231 ₆ 6 37 1 231 ₆ 9 37 | 3 231,9 37 1 232,1 37 | 12 232-1 37 | 23003 31 | | 2 1 239,7 37 | 36E 26 25 240.2 37 | 26 240,2 37 26 240,2 37 |
| 4 23 219.4 | | 22 24 219 ₅ 5 1 22 219 ₉ 5 1 1 221 ₉ 3 | TRACKR 1 1 226.8 | 2 1 229,2 | 1 1 229,5 | 21 21 230,0 3 | 22 22 230.0 36 | | 25 25 230•0 | 7 0.0 8 | | 31 31 230,0 37 | 34 34 230.0 37 | | : 37 37 230 ₆ 0 37 | RELF 23 22 230.7 37 | | 4 14 231.6 37 2 1 231.9 37 | 2 3 231,9 37 1 1 232,1 37 | 1 12 232-1 37 | TO DOOD TO A CONTROL A CONTROL | | TRACKR 2 1 239.7 37 | EMERGE 26 25 240.2 37 | 26 26 240,2 37 1 26 240,2 37 |

| | 544.1 | 543.9 | 245.0 | 243.6 | | 243.9 | | 245.0 |) ! ! | 257.3 | 251•3 | 254.0 | 251.6 | 251.7 | | 531.2 | 256.6 | 556.6 | 255.7 | | 256.6 | | 256.6 262.3 | | 269•3 | 261.3 | 262.0 | 264.0 | 261.5 | 261.5 | 44 |) | 0 + 407 |
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| 37.841 | 37.861 | 37.880 | 47.900 | | 37.979 | | 38.296 | | 38,375 | 38•390 | 38.409 | 38.428 | 38.436 | | 38.459 38.464 | 38.483 | 38.503 | | 3 | 38•592 38•596 | | 38.907 | | 36.986 | 39.001 | 39,021 | 39.041 | | | 39.087 | 39.089 | 39.114 | |
| 240.3 | 241,3 | 242.4 | 743.6 | | 243.6 | , | 243.9 | i | 245.0 | 248.6 | 251.3 | 251.6 | 4 140 | | 251.6 | 254.0 | 254.0 | | | 255.7 | | 256.6 256.6 | | 256.6 257.3 | 258.7 | 259.3 | 261.3 | 1 1 7 6 | 2 1 | C • 1 • 2 | 261.5 261.5 | 262.0 | |
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| OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | | OCCURRENCE OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | 30000 | OCCURRENCE | OCCURRENCE | FUNHABILITY | | 3 | OCCURRENCE | | OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | FUNDARIOUS | CCCURRENCE | | 300000000000000000000000000000000000000 | OCCURRENCE | OCCURRENCE | OCCURRENCE | |
| 815 | 816 | 817 | | 2 | 819 820 | | 821 822 | | 823 | | 80.6 | 827 | | 0 | 829 830 | 831 | 25 | | 2 | 834 | | 836 837 | | 838 839 | | 149 | | | 7 | 4 | 845 846 | 847 | |

| | 265.0 | 266.7 | 267,3 | 267.7 | 266.7 | • 003 | 267.3 | | 267.7 | • | 281.3 | 270.9 | 271.0 270.9 | | 273.6 | 553.4 | 276.3 | 277.6 | 279.0 | 280.2 | 279.0 | | 280.1 280.1 | 294•0 | 280•1 | 280.2 |) : : | 280.2 | r 90 | 1 6000 | 293,3 | 290.7 |
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| 39,133 | 39.152 | 39,172 | 39,190 | 30.210 | | 39.291 | | 39.375 39.379 | | 39.459 | 39.473 | 39.481 | | 39,503 39,508 | 39.536 | 39.558 | 30.578 | 2 6 | 040.40 | 39.015 | 39•635 | 39.988 | ! | 40.04 40.098 | 40.103 | | 40.134 | | 40.221 40.225 | 40.247 | 40.257 | |
| 262,3 | 264.0 | 264.6 | 265.0 | 266.7 | • | 266.7 | | 267,3 | | 267.7 | 270.9 | 270.9 | | 270.9 | 271.0 | 273.6 | 274.9 | | 2017 | 5//5 | 279•0 | 279.0 | | 280.1 | 1.080 | | 280.1 280.2 | | 280°5 280°5 | 281,3 | 290.7 | r |
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| 848 | 849 | 850 | 851 | 8 7.2 |) | 853 478 | | 855 856 | | 857 858 | 859 | 960 | | 861 862 | 863 | 864 | 2,4 | 3 | | o R | 868 | 869 870 | | 871 872 | | | 875 876 | ı | 877 878 | 819 | 980 | |

| 301.3 | 291.1 | 291.2 291.1 | | 291.1 291.1 301.0 | | 536.3 | 305,3 | 296.7 | 299.3 | 302.0 | 303.7 | 304.0 | 301.6 | 301.7 | i | 9.100 | 304. | 303.7 316.1 | 304.0 | 315.1 | 304.7 309.5 | 455.9 | 17. | 312.2 | 6.016 | | 310.3 | 561.2 | 314.8 |
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| 4E 0 | 4 | | 291.1 40.378 291.1 40.383 | | 291.1 40.776 291.1 40.780 291.2 40.784 | • | 40.8 | . 4 | | | . | · · | 301.6 40.923 | 2 | 301.6 40.946 301.7 40.951 | 302.0 40.971 | 303.7 40.992 | | 303,7 41,380 304,0 41,384 | ; | 304.7 41.4682 | 304.7 41.567 304.9 41.571 | | 309.5 41.603 | 310,2 41,624 | 310,2 41,632 | | | 312,2 41,679 |
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| 7.044 | | 332.6 315.1 | 325.2 | 316.1 333.4 | 467.8 | 329.3 | 320.2 422.1 | 320.3 320.2 | 570.4 | 473.9 | 327.9 | 327.9 | 341.3 | 480.5 | 331.0 853.7 | 331.1 | 0.155 | 577.4 | 335,3 | 336.1 | 484.1 | | 3.56.6 | 340.0 | 338.7 345.6 | 340.0 |
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| 36 | , w. | ლ ლ ე 4 | 35 | տ ա Ֆ ւն | 34 | 94 | გ გ 4 ც | 36 | 35 | 34 | 34 | 3.5 3.5 | 34 | , w | 3.4 3.5 | 35 | 95 | 35 | 35 | 35 | 35 |) i | ς i | r C | 35 36 | 35 |
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| ٠ | | - ~ | ı ~ ı | 44 | 13 | - | 33 | 33 | 33 | 2 | 8 | ~ ~ | - | · :: | 3 98 | 36 | - | 36 | - | 4 | oo - | ٠, | , | - | 4 4 | 39 |
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| 41.700 | 41.720 | 41.811 | 41.906 | 42.307 | 46.311 | 42,343 | 356.24 | 42 43 48 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 | 42,483 | | 62.463 | 9.539 | 42,543 | 42.553 | 45.574 | 42.587 | 42.609 | 42.633 | 42.666 | 42.686 | 42.708 | 42.731 | 42.752 | 42.773 | | 43.150 43.154 |
| 312,7 | 314.8 | 314,8 315,1 | 315,1 | 316.1 | 317.3 | 0.000 | 0 00 | 2 8 | 320.3 | | 30030 | 327.9 | 329.3 | 330.4 | 331.0 | 331.0 | 331.0 | 332.6 | 333.4 | 335.0 | 335,3 | 336.1 | 337.9 | 338.7 | | 340.0 |
| ^ | - | 12 | s - | 1 2: | <u>:</u> - | • ह | ; ; | 8 8 | ы ы п | | • - | . ñ | 7 → | :: | 9. 4. | 36 | 36 | - | | o o | - | - | - | - | | 37 |
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| 914 | 918 | 916 917 | 918 | | | 326 | , , | , r | | 2 6 | 8 00 6 0 | | 931 | 932 | 933 | 934 | 935 | | 938 | 636 | 940 | 941 | 945 | 943 | | 944 945 |

| 340.1 | 340.0 | 2.065 | 340.6 346.3 | 350.4 |) i | 345.3 | XO. | 348•3 | 349.0 | 350.7 | 350.9 | 351.7 | 362.4 | 350.7 | 362.8 | | 350.9 | 358.4 | 1 1 1 1 | 363.0 | | 2009 | 361.1 | 510.8 | 363.8 | 374.4 | 362.8 | 362.8 |) | 363.0 | 363.8 |
|------------|---|------------|------------------|------------|------------|------------|--|------------|------------|------------|------------|------------|------------|--------|--------|------------------|------------|------------|------------|-------------|--------------------------|------------|------------|------------|---|--------------------------|------------|------------|--------------------------|------------|--------------------------|
| 35 | 36 | 35 | 35 | 35 | 2 | e d | Š | 36 | 36 | 36 | 36 | 36 | 36 | 35 | 3.5 | | 35 | 36 | ď | 0 9 9 | | 35 | 35 | 35 | 35 | 35 | 35 | 37 | i | . 85 K | 35 56 |
| 35 | o m | 36 | 17 1. | 7 | | - | - | - | | - | - | - | - | 2,5 | Ş - | | 81 | - | 9 | <u>,</u> - | | 19 | ~ | 4. | - | ~ | 90 | ρ ¬ | I | 21 | , ¥ |
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| 340.0 | 340.0 | 340.6 | 340.6 | 341.3 | 342.7 | 345,3 | 345.6 | 346.3 | 348.0 | 348,3 | 349.0 | 350.4 | 350.4 | | | 350.7 | 350.9 | 50. | 351.7 | | 351.7 355.2 | 358.4 | 359.1 | 361.1 | 7 6 7 6 | ****** | 304.8 | | 362.8 362.8 | 363.0 | 363.n 363.8 |
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| 946 | 947 | 646 | 950 | 951 | 825 | 953 | 924 | 955 | 926 | 756 | 958 | 959 | 960 | | | 963 | | | 996 | | 967 968 | 646 | 026 | 97.1 | | 2 6 | 5/6 | | 974 975 | | 977 978 |

| 371.0 | 517.4 | 370.9 | 373.5 | 373.7 | 376.2 | 376.3 | 386.4 | • | 374.8 | 374.8 | | | | 385.9 | | 376.3 | 376.3 | 376.3 | 388.0 | | | | 530.7 | 388.6 | 40B. | ٠. | 388.0 | | 388.6 | | 302.6 | • | 393.6 | 6 | 393.6 | 393.6 | 393.6 |
|------------------|--------|---------|--|--------|------------|------------|------------|--|--------|--------|------------|------------|------------|--------|------------|------------|------------------|--------------|--------|------------------|------------|------------|---|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------------------|---------|-----------------------|--------------------------|
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| 363.8 | 0.00 | | 2 5 | | 6.576 | 373.7 | 374.4 | 374.8 | | | 374.8 | 374.8 | 376.2 | | 376.2 | 200 | | | | 376.3 | 376,3 | 376,3 | • | 385.9 | 386.4 | 388.0 | | 388.0 | | 388.6 | 393.6 | 393.6 | 393.6 | 393.6 393.6 | ć | 393,6 | 393.6 393.6 |
| 24 | : - | • - | ٠. | • - | ٠. | - | - | - | | | 92 | 8 8 | - | | 91 | • | | | | 6 E | 35 | 31 | 3 | - | - | - | | 55 | • | 10 | 37 | 37 | 34 | 34 31 | ř | 3 8 8 8 8 | 22.2 |
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| OCCURRENCE | | | | | מכנחאבותנב | OCCURRENCE | OCCURRENCE | OCCURRENCE | | | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | | | | OCCURRENCE | OCCURRENCE | OCCURRENCE | 200000000000000000000000000000000000000 | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | | OCCURRENCE | OCCURRENCE OCCURRENCE |
| 979 | | , , | 7 6 | 6 | 996 | 985 | 986 | 784 | | | | 686 6 | | | 266 | 666 | | | | | | 997 | | 666 | 1000 | 1001 | | 1002 | | 1004 | 1005 | 1006 | 1007 | 1008 | | 1010 | 1012 |

| | 393.6 | , , | 993.6 | 397.0 | 397.8 | 399.7 | 4004 | 404.6 | 399.7 | 0.087 | 4.004 | 416.8 | 404.6 | 407.2 | 406.5 | | 407.1 | | 404.8 404.8 | 0.004 | 40.104 | 42.54 | 412,3 | 421.1 | 416.3 | 418.9 | 419.5 | 421.6 | |
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| | 22 | ä | 7 | CJ | 4 | N | 4 | 901 | พพ | 4 | . 4 | 4 | - | - | 901 | • | 901 | • | 901 | - | | • - | • ~ | N 1 | - | - | 4 | 1 | |
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| 46.621 | 46.629 | 46.638 46.644 | 46.654 46.660 | 46.684 | 46.706 | 46.730 | 46.754 | 376.34 | | 46.882 46.486 | 46.902 | 47.014 | 47.055 | 47.078 | • | 47.091 47.097 | | 47.109 47.118 | | 47.129 | 47.159 | 47.169 47.176 | 47.197 | 47.561 47.565 | 47.654 47.658 | 47.679 | 002.27 | | 47.722 |
| 393.6 | 393.6 | 393.6 393.6 | 393.6 394.4 | 395.1 | 397.0 | 397.8 | 408.4 | | | 399.7 | 4.004 | 4004 401.9 | 9.404 | 404 | | 404.6 406.5 | ÷ | 406.5 407.1 | | 407.1 | 8.604 | 409.8 409.9 | 412,3 | 412.3 412.6 | 412.6 416.3 | 416.8 | 0 | F 1 | 419.5 |
| 52 | 22 | 22 | 23 1 | - | - | - | - | | • | w 9 | | . 41 | - | - | • | 16 1 | | 12 | | 4 . ~ | - | 10 | ,~4 | . 23 1 | ຫ | - | | ٠, | |
| 5 | 22 | 22 21 | 22 | 4 | N | 4 | - | . , | v | 4° 0 | 4 | 4- | | - | • | 901 | | 901 | | 901 | - | 901 | ď | 2 | | 4 | | - | 4 |
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| FONERSHOOF | OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | FONTAGE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | 100 C | סככסאוביייכב | OCCURRENCE OCCURRENCE | | OCCURRENCE OCCURRENCE | | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | TON TOOL | | OCCURRENCE | OCCURRENCE |
| | 1015 | 1016 | 1018 1019 | 1020 | 1021 | 1022 | 1033 | 3 | \$ 261 | 1025 | 1027 | 1028 | 1030 | 3 | 1601 | 1032 | | 1034 | | 1036 | 1038 | 1039 | 1041 | 1042 | 1044 | 1006 | | 1047 | 1048 |
| | | | | | | | | | | | | | | ĸ | -59 | | | | | | | | | | | | | | |

| 422.1 | \$ C 7 \$ | 424.3 | 433.8 | 454.8 | 570.4 | 423.8 434.5 | | 424.3 433.0 | | 424.8 428.7 | | 431.3 | 434.0 | 435.7 | 434.6 434.6 | 436.7 | 434.5 | 6 • 1 • 4 | 446.6 | 1 | 435.7 | | 436.7 | . 0.444 | | 4 40 4 | 0 | 460.7 | 447.5 | 456.6 | 454.5 | |
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| 47.743 | 47.764 | 47.786 | 47.796 | 47.818 | 47.827 | | 47.925 | • | 48.018 48.022 | | 48.310 48.314 | 48.335 | 48,357 | 7 | 0 | 48.389 | 48.411 | 48.505 | 48.509 | 48.520 | | 48.618 | | 48.709 48.713 | 48.745 | 48.765 | 48.776 | 661.64 | 49.134 | 49.224 | 49.228 | 49.249 |
| 421,1 | 421.6 | 421,8 | 422.1 | 422.1 | 8.654 | | 423.8 | • | 424 .3 424 .8 | | 424.8 428.7 | 431,3 | 433.0 | | B • 55 • 6 | 434.0 | 434.5 | 434.5 | 434.6 | 434.6 | | 435.7 | | 436.7 | 444.0 | 446.6 | 446.7 | 7.444 | 447.5 | 447.5 | 451,8 | 454.5 |
| - | - | ~ | - | . 6 | : - | • | 12 | Ì | - | | <u>-</u> - | - | - | • - | • | - | - | 18 | - | 71 | | 27 | | 28 1 | - | - | | á | 3 ~ | 19 | - | - |
| ~ | - | 7 | 4 | 33 | , , | ı | ~ ~ | • | -4 | | 4 4 | 4 | - | | - | 4 | N | N | - | 901 | | - - 4 | | 4 (1) | ~ | 1 | N | ^ | . | , | 4 | 4 |
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| 457.2 | 507.5 | 459.3 | 4.59.B | 410.6 | 459.3 470.3 | 459.8 468.1 | 460.7 | 612.5 | 619.1 | 470.8 | 473.0 | 482.6 | 470.8 | 472.6 | 4.0 | 473.0 487.0 | 623.1 | 481.6 | 630.9 | 484.1 | 484° | 633.5 | 484.1 | 484 500°0 |
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| 0 70 | 692.64 | 49.479 | 49.421 | 49.432 | 49.787 | 49.882 2882 | 649.973 | 50.087 | 50.183 | 50.204 | 22 | 50.245 | | 50.00 | 50.700 50.705 | 50.792 | 50.904 | 50.926 | 51.035 | 51.057 | 51.078 | 51.088 | 51.196 | 51.282 51.286 |
| 9 | ¥ 00 0 0 | 456.6 | 59 | 459,3 | 459. 8.99.9 | 459.8 | 7.094 | 67.9 | 468.1 | 470.0 | 470.3 | 470.6 | | 470.8 | 472.6 | 473.0 473.9 | 478.9 | 480.5 | 481.4 | 481,6 | 482.6 | 484.1 | 484.1 | 484.1 484.3 |
| • | ÷ - | - | | - | 23 | 5 | 30 | 13 | ~ | 7 | . | - - | ' ; | ₹. | 25 | E 4 | | : | - | - | - | 00 | - | 32 |
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| 1 | מנים מ | | n S S | 7000 | 7000 0000 | 200 | 200 | 200 | ပ္ပင္ပ | 000 | 200 | ŭ ; | | | ដូច | บัน | 200 | 200 | ည | ည် | ည | 000 | ೧೨೨೦ | 200 000 |

| | 489.6 | 492.3 | 495.0 | 506.6 495.0 | 499.2 | A. 102 | 501.0 | | 2.000 | 7 40 | , n | | 20100 | 507.3 | | 99/e4 | 0.010 | 507.2 528.6 | 507.3 | 523.1 | 508.0 | 513.9 | 662.8 | 516.5 | 519.2 | 668•1 | 530.6 | | 519.2 528.3 | 5,25,8 | | 528.5 |
|------------|------------|------------|------------|----------------|------------|------------|------------|------------|---------------------------------------|------------|------------|------------|------------|------------|------------|------------|---------------------------------------|------------------|--------------------------|--------|------------------|------------|------------|------------|------------|------------|------------|------------|----------------|--------------------------|------------|------------|
| | 27 | 27 | 27 | 27 | 188 | 7.7 | | ; ; | 2 6 | | | ; ; | ù ! | 27 | | , r | ù | 24 28 | 10 | 28 | 72 | 88 | 27 | 27 | 27 | 27 | 27 | ; ; | 24 28 | 7.0 | ; ; | 27 |
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| ٠ | TRACKR | TRACKR | TRACKR | TRESUP | TRACKR | TRACKR | TRACKR | | * * * * * * * * * * * * * * * * * * * | | TOACK | | K (| TRACKR | 2 2 | NOUF | 100 NA 1 | UPDATE TRACKR | 7 Y | TRACKE | UPDATE | TRACKY | NODE | TRACKR | TRACKR | NODE | TRKSUP | | MISSTK | O XO A O T | | TRACKR |
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| 51.373 | 51.409 | 51.430 | 51.450 | 51.460 | 51.813 | 51.817 | 51.837 | 51,858 | 51.878 | 51.899 | 51.919 | 51.941 | 51.961 | 51,983 | 52.003 | 52-114 | 52.124 | | 52.478 | | 52.574 52.578 | 52.664 | 52.068 | 52.778 | 52 • 799 | 52•819 | 52.929 | 52.940 | | 53,285 53,288 | 53,310 | 53,330 |
| 484.3 | 489,6 | 492,3 | 464.6 | 495.0 | 0.884 | 2.664 | 499.3 | 0.002 | 501.8 | 501.9 | 502.7 | 504.5 | 504.6 | 505.4 | 506.2 | 9099 | 507.2 | | 507.2 | | 507.3 508.0 | 508.0 | 510.8 | 513,9 | 516,5 | 517.4 | 518.6 | 519.2 | | 519.2 523.1 | 525.8 | 528.3 |
| 31 | | - | ~ | - | o | - | | - | - | | | - | - | - | 61 | - | - | | 7 7 | | 123 | e ; | 4 | | - | 11 | - | - | | λυ ⊶ | ~ | - |
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| 1114 | 1116 | 1117 | 1118 | 1119 | 1120 | 1121 | 1122 | 1123 | 1124 | 1125 | 1126 | 1127 | 1128 | 1129 | 1130 | 1131 | 1132 | ļ , | 1133 | | 1135 | 1137 | 1138 | 1139 | 1140 | 1141 | 1142 | 1143 | | 1144 | 1146 | 1147 |
| | | | | | | | | | | | | | | | K | -62 | 2 | | | | | | | | | | | | | | | |

| 530.9 | 531.1 | 531,2 | 542.6 | 9 6 6 6 | | 531.1 537.5 | 679.1 | 531,2 | | 684.0 | U.Y. U | 24.0 | 542.2 | 242 | 544.6 | 544.9 | 554.6 | 542.9 | | 693.7 | 544.6 554.3 | 544.9 | 000 | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 1 • • • • • | 702.5 | 554. 565. 0 | |
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| - · | - . | | - € | א נ | S- | 1 • | 56 | 12 | ì | ž, | | • - | . ~ | | | ~ | | 81 | i | 5 | 27 | 28 | 76 | ; - | • ; | c. | ÷ - | |
| 4 (| n, | | - ; | o 4 | 4 4 | NN | 53 | | ' ; | 5¢ . | → (| N 4 | | ۰ ۸ | | - | | N N | ı | 56 | 4 4 | | | j (| u į | 32 | 4 4 | |
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| 53•352 | 53,373 | 53,395 | 53.405 | 53.515 | 53.607 | 53.702 | 53.706 | 53.727 | 54.073 | 54.096 | 54.118 | 54.138 | 54.159 | 54.180 | 54.202 | 54.222 | 54.244 | 54 • 255 | 54.347 | 54.374 | 54.725 | • | 54.817 54.821 | 54.843 | 54.863 | 54.884 | 54.975 54.979 | |
| 528.5 | 528.6 | 530.6 | 530.7 | 530.9 | 530.9 | 531.1 | 531.2 | 531.6 | 531.2 536.3 | 536.9 | 537.5 | 539,3 | 539.5 | 540.2 | 542.0 | 542,2 | 542.6 | 542.9 | 542.9 544.1 | 544.6 | 4. | | 544.9 551.6 | 552,1 | 553.4 | 554.3 | ង្ | |
| - | - | - | 20 | - | 23 | • = | Š, | - | 24 | ~ | ~ | - | ~ | - | p=4 | - | - | | 18 26 | | 27 | • | 28 | - | 35 | - | 61 | |
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| TRACKR | TRACKR | TRKSUP | NODE | TRACKR | UPDATE | UPDATE | NODE | TKACKK | MISSTK | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRACKR | TRKSUP | TRACKR | UPDATE NODE | TRACKR | UPDATE | A A A | UPDATE | TRACKR | NODE | TRACKR | UPDATE | |
| OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | |
| 1148 | 1149 | 1150 | 51 | 1152 | 1153 | | 1156 | 1157 | 1158 | 1160 | 1161 | 1162 | 1163 | 1164 | 1165 | 1166 | 1167 | 1168 | 1169 | 1171 | 1172 | 77 | 1174 | 1176 | 1177 | 1178 | 1179 | |

| 9*995 | 554.7 | } | 560.6 | 563,3 | 713.0 | 566.0 | 714.9 | 567.7 | 567.8 | 566.0 | 571.5 | 578.6 | 567,7 | | 567.8 | - ! ! | 574.1 | 576.8 | 577.2 | 579.5 | 579.9 | 726.9 | 580.4 | 4.092 | 579.5 | 584+3 | 579.9 | | 580.1 | 601.2 | 621.7 | 700.0 | |
|--------|-------------|------------------|------------|------------|------------|-----------|---------|--------|------------|------------|----------------------|---|--------|------------|--------|--------------------------|------------|------------|-------------|--------|------------|------------|------------|------------|------------|------------|---|--------------------------|-----------|--------|---------|----------------|------------|
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| 000 | 694.46 | 55.081 55.086 | 55.117 | 55,139 | 55.159 | 181 | | 10166 | 55•255 | 55.243 | 55 • 594 55 • 598 | 904.22 | | 55,693 | | 55.785 55.789 | 55.810 | 55,830 | 28.72 | | 55.672 | 55.693 | 55.913 | 55.934 | 55.944 | 56.291 | 643.00 | 56+382 56+386 | | | | | 56.507 |
| 1 | . • • • • | 554.7 558.0 | 560.6 | 561.2 | 563.3 | 164.0 | | 0 | 565.1 | 566.0 | 566.0 | 2 4 4 3 | 5 | 567.7 | ò | 567,8 571,5 | 574.1 | 574.5 | | | 577.6 | 577. | 577.7 | 578.6 | 579.5 | 579.5 | 7.670 | 579.9 580.0 | | | | | 580.1 |
| • | - | 20 | - | 30 | | ç | ; - | • | | - | 18 | - | • | 55 - | • | 77 | | ~ | • - | • • | - ; | 8 | | ~ | - | 19 | • | w 0 | | | | | 40 |
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| : | 1811 | 1182 | 1184 | 1185 | 1186 | 1.07 | | 0011 | 1189 | 1190 | 1191 | | | 1194 | | 1196 | | 1199 | 2001 | 0021 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | | 1208 1209 | | | | | 1210 |

| • • | 265 265 | 733.6 | 586.8 | 587.0 | 589.5 | 589.6 | 589 | | 592.3 | 740.4 | 9050 | 8*165 | 596.3 | 592.3 | • | 592.7 | | 598.4 | 601.1 | 601.6 | 601.1 | | 601.2 | 632.4 605.6 | 601.6 | | 9.4.0 | 605.1 615.0 | | 608.7 |
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| Ç, | 3→ | 38 | - | - | ~ | - | 18 | • | • ; | Э. Э. | → (| y (| 4 4 | 29 | | 52 | | ~ | - | - | 19 | , | £ ; | 4 4 9 9 | 5° 1 | - | • | 33 1 | | - |
| c | u ru | 38 | 4 | ٦ | * | - | 4 4 | | - | œ , | → (| y (| 4 | | • | N N | | 4 | 4 | 7 | 44 | • | £43 | 4 6 u | | | → | (1) (V) | | 4 |
| 4 | A A A A A A A A A A A A A A A A A A A | NODE | TRACKR | TRACKR | TRACKR | TRACKR | UPDATE | | A A C | NODE | 408 N | 300V | RODE | UPDATE | | UPDATE | | TRACKR | TRACKR | TRACKR | UPDATE | | NODE | NODE ENTER | UPDATE | | TRKSUP | UPDATE TRACKR | | TRACKR |
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| 56.511 | 56.599 | 56.624 | 56.644 | 444 | 707 | 200 | 900 | 56.799 56.803 | 56.825 | 56.845 | 56.855 | 56.863 | 000 | 00.00 | 57.242 | | 57,333 57,337 | 57.357 | 67.303 | 0 0 d - F | 200 | 57.493 | 57.505 | 1 | 57.531 | 57.620 57.624 | 57.634 | | 57.998 58.002 58.002 | |
| 580.4 | ຄ ຄ ຄ ຄ ວ 4 | 584.1 | 48. | 9 4 | | | 6.00 | 589 . 5 | 590.2 | 590.6 | 591.8 | 591.8 | 6 | 592.3 | 592.3 | | 592,7 595,8 | 596.3 | 9 9 | | 100 | 601.1 | 601,2 | , | 601.6 | 601.6 602.6 | 605.1 | • | 605. | • |
| | 30 | | | | • - | | - | 18 | 39 | - | 04 | 42 | • | - | 53 | • | 52 | 42 | | ٠ - | • | 19 | 6 4 | | | 24 1 | | | 6. 4. 6. 6 | • |
| 8 | 38.2 | 4 | . " | ٠ ، | | • • | t | 4 ~ | 39 | ٦ | 45 | 45 | • | - | - 2 | ı | W 4 | - 4 | | - 4 | • | 4 10 | 43 | | | | N | ı | ~ ~ | + |
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| 1211 | 1212 | • | 7101 | 1216 | | 121 | 1210 | 1219 1220 | 1221 | 1222 | 1223 | 1224 | | 1225 | 1226 | | 1228 | | | 1636 | 1633 | 1234 | | 1 | 1237 | 1238 1239 | 1240 | , | 1241 | |
| | | | | | | | | | | | | | | F | 7- 6 | 5 | | | | | | | | | | | | | | |

| | 607.2 | 611.2 | 611.3 | 611.2 618.7 | | 614.0 | 611.8 648.7 | 643.6 | 2 0 | 6.210 | 614.0 | | 614.6 615.6 | ı | 615.0 619.3 | | 616.4 | | 617.9 | | 659.9 | 621.4 | 619.1 | | 621.9 | 624.1 | 621.7 | 653.1 | 4.464 | 623 | 1 • 6 3 9 | 664.5 |
|------------|------------|------------|------------|----------------|------------------|------------|----------------|------------|------------|------------|--------|------------|------------------|------------------|----------------|------------|--------|------------------|-------------|------------------|------------|------------|------------|--------------------------|------------|--------|--|--------------|------------|------------|---|------------|
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| 1 | ~ | ~ | | 97 7 | | | :: | ** | , , | • | 22 | | 3¢ T | | 2 1 | | 18 | , | - 61 | | - | - | • | • | - | - | 5 | ֆ ֆ ւն ւն | ! - | | - | 42 |
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| 58.028 | 58.037 | 58.068 | 58.088 | | 58.178 58.183 | 58,203 | | 28.619 | 58.243 | 58.253 | | 58,355 | | 58.386 58.390 | | 58.479 | | 58.496 58.501 | | 58.512 | 58•530 | 58.038 | 58.570 | 58.580 58.589 | 58.609 | 004 | 100 to 10 | 0.00 | 58.663 | 58,683 | 58.693 | 20.00 |
| 507.2 | 607.2 | 608.7 | 611.2 | | 611.2 611.3 | 611.8 | | 9119 | 612.5 | 612.5 | • | 614.0 | | 614.6 615.0 | | 615.0 | | 616.2 | • | 616.4 | 617.9 | | 619.1 | 619.1 619.3 | 621.4 | | | 961. | 65139 | 623,1 | 623.1 | 0630 |
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| OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | | OCCURRENCE | | OCCURRENCE | | OCCURRENCE | 300000 | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE OCCURRENCE | OCCURRENCE | | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE | OCCURRENCE |
| 1244 | 1245 | | 1248 | | 1249 | | | 1252 | 1253 | 1254 | | 1256 | | 1258 | | 1260 | | 1262 | | 1264 | | | 1268 | 1269 | | | 12/2 | 1273 | 1274 | 1275 | 1276 | |

| 624.1 | 626.4 | 627.3 | 6529 | 634,4 | | | 626.4 | | 627.3 632.5 | | 629.9 | 630.9 | | 631.2 | 662.9 | 673.4 | 633.1 | 1.000 | 632,5 638,0 | | 634.2 634.2 | 633,5 | 635.0 | | 637.0 | 637.4 | 636,2 | 0 4 4 | • |
|------------|------------|------------|------------|------------|------------|--------------|---------------|------------------|----------------|------------|-----------------------|--------------------------|------------|--------|---|------------|------------|------------|----------------|------------------|----------------|------------------|--------------------------|------------|--------|------------|------------|--|--|
| 58 | 30 | 62 | 62.6 | 31 | | | 8 5 7 8 | | 8 6 7 | | 8 8 8 8 8 | 80 | | 27 | 27 | 28 | 58 | Š | 5 0 8 8 | i | 3 C | 5 | 8 0 | ì | 88 | 88 | 28 | | ŭ |
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| - | - | N | 50 | + 4 | | | | • | u vi | | | = | : | 4 | 4 ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° | 4 | | 106 | ~ ~ | | 106 | 60 | 1 00 | • | 4 | - | 901 | • | - |
| MISSTR | TRACKR | TRACKR | LATESP | TRACKR | | | MISSTK | | MISSTK | | LATEDT | 108021 | | NODE | NODE Enter | NODE | TRKSUP | DROPIK | UPDATE | i | TRKSUP | IMPACT | TAKSUP | | TRACKR | TRACKR | TRKSUP | | 200 200 200 200 200 200 200 200 200 200 |
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| 58,721 | 59.043 | | 190.46 | | 59.172 | 59.179 | | 59.265 59.268 | | 59,349 | | 59,380 | 59.393 | 414.02 | | 59.441 | 59.461 | 59.472 | | 59.561 59.565 | | 59.576 59.584 | 59°593 59°602 | 59.614 | 50.643 | | 59.664 | 59.676 59.682 59.687 | 59.697 59.704 |
| 624.1 | 624.1 | | 6656 | | 625.9 | 626.1 | • | 626.4 | | 627.3 | | 629.9 630.9 | 630.9 | 6 167 | 3 | 632.4 | 632.4 | 632,5 | | 632.5 633.1 | | 633.1 633.5 | 633°5 634°2 | 634.2 | . 767 | • | 635.0 | 635.0 635.7 636.2 | 636.2 637.0 |
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| 1278 | 1279 | | 1281 | | | 1284 | | 1286 | | 1288 | | 1290 1291 | 1292 | | 1294 | 1295 | 1296 | 1207 | 1631 | 1298 | | 1300 | 1302 | 1304 | 0001 | 1306 | 1307 | 1308 1309 1310 | 1311 1312 |

| 637.0 | 0.46.9 | 640.1 | 638.0 | | 640.1 | | 642.9 | | 685.1 | 646.3 | 648.9 | 650.4 | 648.2 | 650.4 | 685.1 | 648.9 | 0./60 | 650.1 | | 650.4 | 4.054 | 661.6 | 6 | 0 • 700 | 694.5 | 655.5 | | 659.7 | 657.4 | | 659.7 | 661.6 | |
|--------|--------------------------|------------|--------|--------------------------|------------------|------------------|--------|----------------|------------|--------|----------|------------|------------|---|------------|--------------|------------|---------------|------------------|------------------|--------------------------|----------------|--|------------|--------------|------------------|--------------------------|------------|------------|------------|--------|------------------|---|
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| | 60.030 | 60.054 | | 60.132 | | 60.212 | | 60.299 | 60.322 | | Tereno | 00000 | 60.379 | 60.406 | 60.420 | | 50.502 | ₹ | 60.825 | | 60.857 60.861 | | 60 • 946 60 • 950 | 096.09 | 40.040 | | 61.063 | | 61.088 | 61.097 | • | 61.190 61.194 | |
| | 637.0 | 638.0 | | 638.0 | . : | 640.1 | | 642.9 643.6 | 643.6 | | 2.040 | | 648•2 | 648.2 | 6,849 | | 648.9 | 1000 | 650.1 650.4 | | 650.4 650.4 | | 650.4 650.8 | 653,1 | 9 997 | | 655.5 657.0 | | 657.4 | 657.4 | • | 659.7 661.6 | |
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| | 1313 | 1315 | | 1316 1317 | | 1318 | | 1320 1321 | 1322 | | 6361 | 1324 | 1325 | 1326 | 1328 | • | 1329 | | 1331 | | 1333 | | 1335 | 1337 | 955 | 200 | 1339 | | | 1342 | | 1344 1345 | |

| 665.2 | 666.2 | 2.000 | 900 | 704.3 | 664.3 | 0.0 | 673.7 | 665.2 | 0 | 667.4 | | 679.4 | 667.8 | 1 077 | 675.0 | 668.1 | | 672.4 676.8 | 682.5 | 1 0 | 675.0 | 678.2 | 676.2 | 676.8 | 687.2 | 678.2 | • |
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| 61.272 61.276 | 61.297 | 61.309 | 61.318 | 61.347 | | 61.655 61.659 | 61.664 | 61.683 | 61.762 | | 61.777 61.786 | 61.797 | ; ; | 61.876 61.880 | | 61.952 61.956 | 61.966 61.975 | | 62.051 62.054 | 62.074 | 62.093 | 62-120 | 121.20 | 62.197 62.201 | 62.475 | 67.413 | 62.554 |
| 661.6 661.6 | 662,8 | 662,8 | 662.8 | 664.3 | | 664.3 | 664.5 | 665.2 | 665.2 | | 666.2 667.4 | 667.4 | • | 667.8 668.1 | | 668.1 668.1 | 668.1 | | 672.4 673.4 | 673.7 | 675.0 | 675.0 | 7.010 | 676.2 676.8 | 676.8 | 678.4 | 678,2 |
| 27 | - | 74 | 6 | - | • | 39 31 | 42 | - | 11 | • | 20 | 35 | • | 37 | | 36 17 | ~- | | e 4 | 42 | - | 12 | • | . 1 S8 | 30 | - | 38 |
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| 1346 | 1348 | 1349 | 1350 | 1 250 | | 1353 | 22 | 1356 | 1357 | , | 1359 | | | 1363 | | 1365 1366 | 1367 | | 1369 1370 | 1371 | 1372 | 1373 | 13/4 | 1375 | 1377 | 1378 | 1379 |

| | 827.3 | 684.1 684.1 | 4 607 | 980 | 716.5 | 682.9 | • | 832.0 | 685.0 | 9 | 0 | 697.0 | 686.4 | : | 686.8 | | 687.2 693.3 | 5.069 | 694.1 | | 693.3 693.3 698.1 | | | 843.6 | 8.969 | 703.7 | 697.9 | 699.5 | | | 7007 | | 718.2 |
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| | 679.1 | 679.4 | 682.4 | 682.5 | 682.9 | • | 682.9 684.0 | | • • • • | 684.1 684.1 | 685.0 | 685.0 | | 686.4 686.8 | • | 686.8 687.2 | | 690.5 | | 690 . 5 | | 693.3 | 693.7 | 694.1 | | 69445 | 695.2 | 8.969 | 697.0 | 697.9 | 1.869 | 699.5 | |
| | 53 | - | 50 | F 4 | : - | • | 24 | , - | - | 27 | - | m - | • | <u>د</u> د | | 29 | J | 25 | | 3 | | 37 | ⊋ % | _ | | 4 R | | ~ | - | - | - | - | |
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| | 1380 | 1381 | 1382 | 1383 | 786 | 200 | 1386 | | 1388 | 1389 | 1391 | | | 1394 | | 1396 | | 1398 | | 1400 | | 1402 | | 1405 | 1 | 1406 | 1407 | 1408 | 1409 | 1410 | 1411 | 1412 | |
| | | | | | | | | | | | | | | | 77 | 70 | | | | | | | | | | | | | | | | | |

| | 700.0 | 700.5 | 700.7 | | 853.2 | 851.9 | 737.9 | 713.6 | 705.5 | | 710.6 | 708.0 | 709.8 | | 721.8 | 710.6 | | 712.1 | | 865.2 | 747.9 | 866.2 | 715.8 | ! | 716.5 | 717.1 | 9 | 722.9 | 723,3 |
|--------------------------|--------------------------|------------------|---|--------------------------|------------|------------|--------------|------------|--------------|--------------------------|------------|------------|---|------------|------------|---------|------------|----------------|------------------|------------|------------|------------|--------|--------------------------|------------|--------|----------------|--------------|--------------------------|
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| 63.765 63.769 | 63.779 | 0. | 10.5 | 63.879 | 63.993 | 64.087 | 401.44 | 801.44 | | 64.339 64.343 | 64.361 | 64.372 | | 64.393 | 64.403 | • | 64.478 | | 64.549 64.553 | 649.49 | 64.667 | 64.762 | • | 64.818 | 64.831 | | 64.905 | | 65.100 65.104 |
| 699.5 | 700.0 | 700.5 | • | 700.7 | 702.5 | 703.7 | 704.3 | 705.5 | 9 | 705.5 | 708.0 | 708.0 | • | 109.8 | 709.8 | | 710.6 | | 712.1 | 713.6 | 714.9 | 715.8 | | 715.8 | 716.5 | ı | 717.1 718.2 | 1 | 718.2 |
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| 1 4 | 4 © 0 | N 4 | • | 24 | 35 | ą. | 4 | ٠ م | • | W 4 | 4 | 4 - | - | - | 901 | | 4 N | | N 0 | 9 | 25 | | 1 | | 4 W 4 | | 4 ~ | | 4 |
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| 1413 | 1415 | | 0.7 | 1419 | 1421 | 1422 | 1423 | 1434 | | 1425 | 1427 | | | 1430 | 1431 | | 1433 | | 1435 | | 1438 | 1439 | | 1440 | 1442 | | 1444 1445 | | 1446 |

| 4 | - | 721.8 728.6 | 722.9 | 1.63,1 | 723,3 | 727,3 | 723.8 | | 876.6 | 727.3 | | 729.9 | 729.1 | 735.5 | 731.9 | 741.9 | | 734.6 | 883.5 | 736.6 | 734.6 | | 735.5 | | 736.6 | 1 | 5.5 | 739.8 |) - - | 740.3 | ! ! ! |
|------------|------------|----------------|------------|---------------------------------------|--------|------------|---------|--------------------------|------------|--------|------------------|------------------|------------|--------------|--------|------------|--------------------------|------------|------------|--------|---------------------------------------|------------|----------|--------------------------|----------|--------------------------|---------------------------------------|------------|---------------|------------|--------------------------|
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| 721.2 | 721.8 | 721.8 | 722.9 | 722.9 | • | 723.3 | | 723.8 | 727.3 | | 727.3 | | 729.1 | 729.1 | | 64.6 | 729.9 | 733.6 | 734.0 | | 0 • • • • | 734.6 | | 735.5 | | 736.6 | 737.9 | 739.8 | 739.8 | 740.3 | 740.3 |
| ~ | - | 7 | - | =- | • | 31 | • | 28 36 | ~ | | . 36 | · | ~ | ن - س | • - | - | 7 | 38 | _ | | - | 15 | , | 30 | | 25 25 35 | 7 | - | 38 | | 3.0 4.0 9.0 |
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| 1448 | 1449 | 1450 | 1451 | 1452 | • | 1454 | | 1456 | | | 1459 | | 1461 | 1462 | | 1404 | 1465 1466 | 1467 | 1468 | | 1464 | 1470 | | 1472 | | 1474 | 1476 | 1477 | 1478 | 1479 | 1480 |

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| 1483 | OCCURRENCE | TRKSUP | - | - | 743.2 | 66.403 | INSERT | TRKSUP | 1 00 | . → . | 17 | 746.1 |
| 1484 | OCCURRENCE | DROPTK TRACKR | 901 | 12 1 | 743.2 | 66.415 66.424 | | 2 | 106 | ; | 0 | • |
| 1486 | OCCURRENCE | TRACKR | ~ | - | 744.6 | 66.441 | INSERT | TRACKR | 4 | - | 11 | 747.0 |
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| | | | • • | • - | | | INSERT | TRACKR | ~4 | | 11 | 748.0 |
| 1489 | | DROPTK | 901 | 1 1 | 746.1 | 66.488 | INSERT | TRKSUP | - | 7 | 1.7 | 758.1 |
| 1490 | | TRACKR | 4 | ~ | 747.0 | 66.494 | INSERT | UPDATE | 44 | 29 | 16 | 747.0 |
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| • | - | ம் ு | - | - | 9 | ğ ~ | - | - | _ | • - | • | 33 | | 87 | | =- | | - | - | - | 36 | - | ~ | 38 | ~ | | 5¢ 1 | | 82 ~* | - | - | • | • |
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| 818.0 | 0.010 | 0 0 | 017.5 | 821.5 | 830.0 | 818.5 823.1 | | 823.7 | 5 | 831.7 | 825.7 | 426.4 | 828.4 | | 829.1 | 827.3 | 831.1 | 829.1 | 0000 | 830.4 | 842.4 | | 831•1 | | 839.7 | 832.0 | 1 | 833.5 839.4 | 840.4 |
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| 815,3 | 815,8 | 816.7 | 817.5 | 817.5 | 818.0 | n • 0 • 0 | 818.5 | | 819.3 821.5 | | 821 . 5 823.1 | 823.7 | 825.7 | 826.4 | 827.3 | F . 758 | 828.4 | 829.1 | 829.1 | 830°0 | 830.4 | 830.4 | | 831.1 | | 831.7 832.0 | 832.0 833.5 | | 833.5 837.7 |
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| 1581 | 1582 | 1583 | 1584 | 1585 | | | 1589 1590 | | 1591 1592 | | 1593 | 1595 | 1596 | 1597 | 1598 | | | 1601 | 1602 | | 1604 | 1605 | | 1607 |)) • | 1609 1610 | 1611 | | 1613 1614 |

| 0.62 | | 4 . | 343.1 | 842.0 850.1 | 842.4 | | 842.6 842.6 | 854.6 | 4.648 | 843.1 | 850.3 | 843.6 | 847.9 | 847.9 | | 853.0 | 851.9 | 852.1 | | 855.6 | 7 7 7 | 0.0 | 858.6 858.6 | 855.6 856.9 | • | 862.0 | 861.6 | ! ! |
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| 839.4 | 839.7 | 840.4 | 842.0 | 842.0 | <u>.</u> | 842.4 842.4 | | 842.6 | 842.6 | 842.6 843.1 | 843.1 843.6 | 843.6 | 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | | 847.9 850.1 850.3 | 851.9 | 851.9 852.1 | | 852.1 853.0 | 853.2 | 853,2 853,7 | 854.6 | 855.6 | | 855 . 6 858 . 6 | 958.6 | 858.9 | 860.9 |
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| 1615 | 1616 | 1617 | 1618 | 1619 | | 1621 | | 1623 | 1624 | 1625 1626 | 1627 1628 | | | | 1632 1633 1634 | 1635 | | | 1638 1639 | | 1641 1642 | 1643 | 1644 | | 1645 1646 | | 1648 | 1649 |

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| | 860.9 861.6 | 862.0 | | 862.0 | 862.7 | : | 864,2 | 865.2 | • | 865.7 866.2 | 866.2 | • | 870.9 871.0 | 873.7 | 874.7 | • | 874.7 875.3 | | 875.3 876.3 | 877.3 | | 878.5 | 878.5 879.0 | | 879.0 883.2 | 883.4 | 883.5 | 883,5 | 885,9 | 885.9 886.0 |
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| | 1650 | 1652 | | 1653 | | | 1657 1658 | 1659 | | 1661 1662 | 1663 | | 1665 1666 | 1667 | 1668 | | 1669 | | 1671 1672 | 1673 | | 1674 | 1675 1676 | | 1677 1678 | 1679 | 1680 | | 1682 | 1683 1684 |

| 888.7 | 898.7 | 0 00 | 891.1 | 891.1 | • | 891.2 891.2 | 891.1 | 903.2 | | 897.9 | 897.9 902.6 | 905.3 | 915.2 | 6.706 | 910.6 | 910.6 | 41409 | 917.5 | 917.8 | 920.2 | 929.8 | | 922•9 | 922.9 | ; | 931.0 | 941.8 | 933.7 | 936.4 | |
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| | 71.056 | 71.119 | 71.135 | 71.146 | 71.157 | | 71.183 | 71.195 | 71.210 71.220 | | 76301 | 71.252 | 71,269 | 71.279 | 71.291 | 71.303 | 71.346 | 71.350 | 71.364 | 71.376 | 71.388 | 71.397 | 71.416 | | 71.458 | 71.475 | | 71.484 | 71.495 | 71.507 |
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| | 1685 | 1686 1687 | 1688 | 1689 | 1690 | | 1692 | 1693 1694 | 1695 | | 1698 | 1699 | 1701 | 1702 | 1703 | 1704 | 1705 | 1706 | 1707 | 1708 | 1709 | 1710 | 1712 | 3 | 1713 | , , | 1715 | 1716 | 1717 | 1718 |
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| 936.4 | 638.6 | 941.5 | 2.446 | 953.8 | 6.946 | | 946.9 949.8 | | 949.8 | | 955.1 | 955.4 955.4 | 7.126 | | • / 0 6 | 4.096 | 963.1 | 965.7 | | 968.4 | 919.4 | 971.1 | 973.7 | 973.7 | | 7.086 | 1.086 | 992.7 | 7.086 | | |
|--------|------------|------------|------------------|--------|------------|------------|----------------|--------------|--------|------------------|------------|------------------|------------|------------|--------------------------|--------------|--------|------------|------------|------------|------------|------------|------------|------------------|------------------|--------|---------------------------------------|------------|--------|--------------------------|----------|
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| | 936,4 | 7,146 | 0 1 7 0 | | 1 • t | 6*946 | | 946.9 | | 949.8 | 953.8 | | 955.1 | 955.4 | 955.4 | 4 040 | | 963.1 | 965.7 | 967.4 | 968.4 | 971.1 | 973.7 | | 973.7 | | 980.7 | 7.086 | | 980.7 983.4 | 1100 |
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| | MISSTK | TRACKR | TDYGI | | 4 | TRACKR | | MISSTR | | MISSTK TRACKR | TRKSUP | | א א ה | TRKSUP | DROPTK TRACKR | TRACKB | | HACKK K | TRACKR | TRKSUP | TRACKR | TRACKR | TRACKR | , | MISSTK TRKSUP | | TRKSUP | DROPTK | | SLEEP TRACKR | 20075 |
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| | 147005 69046 116075 112899 76495 277491 31186 |
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| | 764757042 495207042 359385803 1310810920 994874279 1433141533 777307997 |
| PERCENT OF 1.79 WE ARL TIME 1.79 B .88 .18 .34 .37 .37 .37 .38 .37 .37 .37 .37 .37 .37 .37 .37 .37 .37 | 456151760 1471192771 143842054 838233526 2011408561 488647611 1805919444 940692737 |
| IME AVERAGE TIME S 1094.00 31.08 6.655 10.00 9.70 9.21 12.42 57.30 7.46 4.17 4.12 4.03 4.03 4.03 4.00 35.07 35.07 | THE X SEQUENCE THE Y SEQUENCE GENERATOR ARRAY ARE 45568 62705432 06493 1213908322 07489 1566918010 61979 384251644 55630 79641228 85037 762323039 25293 762323039 |
| TOTAL TIME SECONDS 1.094 5.439 .133 .235 .235 .235 .235 .235 .235 .235 .2 | 0F 0F 0F 0F 0F 0F 0F 0F 0F 0F 0F 0F 0F 0 |
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| | UNDAMAGED COMPONENTS INITIAL FINAL | 7 | 0 | 0 1 | 5 | 0 (| 9 | • | |
|-----------------|---|-------|-------|-------|-------|-----------|-------|-----------|--|
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| | ENEMY INTENDED | ហ | ۲3 | 0 | • | , | ٥ | 16 | |
| | INTERCEPTS ACHIEVED Umber average range | 0*0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | INTERCE NUMBER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | PRIMARY RADAR DETECTIONS NUMBER AVERAGE RANGE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0•0 | 0 • | |
| BY DEFENSE UNIT | PRIMARY I | 0 | 0 | • | 0 | • | 0 | 0 | |
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PAGE 12

| | NG DEATH MISSILE TYPE | | |
|------------------------|--|---------------------------------------|------------|
| | ID OF UNIT INFLICTING DEATH SHIP G.C. GROUP MISSILE NO. NO. TYPE | | |
| | ID OF SHIP NO. | | |
| | POSITION AT DEATH X | | |
| | DEATH TIME | | |
| | DEF. ASSIGNMENTS MADE LAUN. CMPLTD. | | |
| BY NONIMPACTING TARGET | PARASITES CARRIED LAUNCHED | | 000 |
| æ | TYPE NAME | Augusta | JAT. MEGOS |
| | 161 NO. | • • • • • • • • • • • • • • • • • • • | າທ |
| | 161 NO. | | 4 |

GAME IDENTIFICATION --- SAMPLE SCENARIO

BY PARASITES WHICH ARE NOT KILLED

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|-------------------------------|---------------------|------|-------|------|------|-------|------|-------|------------|------------|-------|------|-------|-------|-------|-------------|-------|-------|-------|-------|-------|-------|-------|------------|----------|-------|-------|-------|------|-------|-------|
| SABLE | LAUNCHERS GUID.CHLS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | • | | 0 | 0 | 0 | 0 | 0 | • | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| NTS DI | RS GUI | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OMPONE | AUNCHE | 0 | 9 | 0 | 0 | 0 | 0 | > | 0 | | 0 | 0 | 0 | | 9 | • | 0 | 0 | 0 | 0 | 0 | 0 | • | 0 | 9 | | 0 | 0 | 0 | • | • |
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| NTS TD | | | 0 | 0 | 0 | | 0 | 0 | • | | 0 | 0 | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0 | | |
| GNME | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DEF. ASSIGNMENTS | | 0 | 0 | 0 | 0 | • | 0 | 0 | 0 | | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| DEF | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ٥ | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| TIME OF | - - - | 07.2 | 623,1 | 12,5 | 33.5 | 624.7 | 30.9 | 619,1 | 62.8 | 37.8 | 68.1 | 57.4 | 82.4 | 14.5 | 32.0 | 43.6 | 53.2 | 27.3 | 65.2 | 56.2 | 73.7 | 51.9 | 76.6 | 83.5 | 6.06 | 95,3 | 080 | 16.5 | 28.9 | 737.9 | 47.9 |
| Y I | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SCHED. | | ❖. | 61.8 | 10.9 | 73.0 | 20.9 | 81.0 | 31,2 | 90.3 | 40.5 | 100.6 | 51.7 | 111,8 | 230.7 | 291.1 | 240.5 | 301.6 | 251.6 | 310.2 | 261.5 | 320.5 | 270.9 | 331.0 | 280.1 | 340.0 | 580.1 | 591,8 | 601.2 | 6119 | 621.7 | 631.2 |
| SHIP | | ~ | ~ | _ | _ | _ | _ | • | _ | _ | _ | _ | ~ | _ | | ~ | _ | • | 9 | r. | 9 | 9 | • | ~ | _ | ~ | ~ | _ | _ | ~ | ~ |
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| ŭ | į | 4SM | VSW. | ¥S.¥ | ASM | 4SM | 4SM | 4SM | ASM MSM | ASM | ASM. | A SM | ASM | ASM. | A SM | ₽S ¥ | 4SM | ASM | ASA | ASM. | ASM | ASM | ASM | ₩S₩ | ASM W | SSM | SSM | SSM | SSM | SSM | SSM |
| TYPE | | • | ** | _ | • | • | • | • | • | • | • | _ | • | • | • | | • | _ | • | • | _ | • | • | • | _ | ٠, | ٠, | ٠, | ٠, | -, | -, |
| TGT | | N | N | N | N | ~ | N | ~ | N | N | N | N | ~ | N | N | ~ | N | N | 2 | N | N | N | ~ | N | N | 4 | 4 | 4 | 4 | 4 | 4 |
| 161 | • | 4 | ហ | ^ | œ | 10 | | 13 | * : | 16 | 11 | 19 | 20 | 23 | 24 | 92 | 27 | 5 | 30 | 32 | 33 | 35 | 36 | 38 | 39 | 41 | 42 | 43 | 4 | 45 | 46 |

GAME IDENTIFICATION --- SAMPLE SCENARIO

SUMMARIES FOR REPLICATION NUMBER

| R OF NEW DETECTIONS SPLIT TRACKS NORMAL LATE NORMAL LATE | DROPPED TRACKS | | | | |
|--|-----------------------|---|---|---------------------------|-------------------|
| N | 42 ON ENIN | MINIMUM O. TIME | E S S S S S S S S S S S S S S S S S S S | MAXIMUM O. TIME | AVERAGE Number |
| ACTUAL UPDATES PER TRACK | 3 | 729.9 | 15 | 891.2 | 4.9 |
| | - | -285.6 | 7 | 164.0 | 1.0 |
| CONCURRENTLY ACTIVE TRACKS | ~ | -649.9 | 26 | 376.3 | 13.0 |
| CONCURRENTLY ACTIVE OPERATORS | ~ | -6529- | e | -283.4 | 2.4 |
| TIME BETWEEN ACTUAL OR ATTEMPTED POSITION REPORTS FOR A GIVEN TRACK (SEC) FOR A GIVEN OPERATOR (SEC) | 13.5 2.6 | ው ቀ ው ው ው ው ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ ፡ | 176.1 31.0 | 664°3 973°7 | 66.2 12.7 |
| RANGE AT TRACK ESTABLISHMENT (KFT) | 24.0 | 721.8 | 1167.6 | 6*6*9= | 6,8,8 |
| | -156.9 -3.6 | 113.0 88.3 821.5 | 152.1 3.1 2566.6 | -247.6 676.8 -307.1 | *.1 *1 *51 |
| POSITION CORRECTION ERRORS BALL TAB (FT) SYMBOL-TO-VIDEO (FT) | 22.4 231.5 | 638.0 829.1 | 2993.0 54205.9 | 668.1 243.9 | 1138,3 4064,9 |
| | 39.4 | 729.9 | 1223,1 | 164.0 | 518,4 |
| AS A TENTATIVE TRACK FOR NEW DETECTIONS (SEC) FOR SPLIT TRACKS (SEC) | 0 0 0 0 0 | 746.1 28.1 | 371.0 229.3 | 650.1 592.3 | 201.6 137.9 |
| | ວ໙ | -300.0 891.1 | 5 17.4 | 163.6 181.0 | 1.8 1.8 |

March 9, 1979

FROM: Code 5308

TO: Distribution List - NRL Report 7958

SUBJ: Radar Surveillance/Radar Tracking Variant of SPEARS

The AAW performance simulation designated SPEARS (System Performance Evaluation and Requirements Simulation) now exists in a version which contains extensive revisions in the areas of radar surveillance and radar tracking. To upgrade the capability of the SPEARS simulation of shipboard radar surveillance, a detailed radar-surveillance model designated SURSEM (Surveillance Radar Systems Evaluation Model) has been modified and incorporated into SPEARS. In addition, a simple tracking algorithm has also been added to replace the implicit assumption that a target track is established instantaneously upon initial detection and then carried automatically until the target either leaves the radar's coverage volume or terminates its flight. Due to time and financial constraints, this version of SPEARS has undergone only limited testing at present.

The attached pages document the radar surveillance/radar tracking variant of SPEARS. They are intended to be integrated into the existing SPEARS handbook, ("SPEARS, An AAW Performance Simulation," D.J. Kaplan et al., NRL Report 7958, June 9, 1976). Pages with page numbers ending in a numeral are meant to replace those with the identical numbers in the SPEARS handbook. Pages with page numbers ending in a letter are intended to follow those with the identical numerical portion in the handbook.

1.6 Radar Surveillance/Radar Tracking Variant

A version of SPEARS is now available which contains extensive revisions in the areas of radar surveillance and radar tracking. To upgrade the capability of the simulation of shipboard radar surveillance, a detailed radar-surveillance model called SURSEM* (Surveillance Radar Systems Evaluation Model) has been modified and incorporated into SPEARS. For each active surveillance radar the SURSEM submodel produces radar single-scan probability-of-detection values as a function of target range and orientation. Actual detections are then determined by Monte Carlo sampling. SURSEM operates within an expanded SPEARS environment which may include wind, rain, and multipath propagation. A surveillance radar is characterized by its radar scan modes. A radar scan mode is a means of defining radar operating characteristics for the illumination of a specific geometrical region. Typical radar scan modes include elevation beams, long-range search, high-angle low-energy search, burnthrough, and horizon scan. For a given radar scan mode of a surveillance radar scan the signal (target), noise, jamming, and clutter energies are calculated for each active target. The probability that the radar scan mode will detect a target is then computed using the userdesignated Marcum-Swerling cross-section model for that target.

A simple tracking algorithm has also been incorporated into SPEARS. The original version of SPEARS assumes implicitly that a target track is established instantaneously upon the initial detection of the target. The track is carried automatically until the target either leaves the coverage volume of the radar or terminates its flight. In this revised version, a target track is established only after three detections by any radars on a single ship within a specified time interval. Target tracks are cataloged and carried by ship or defense unit rather than by an individual radar. The time window for track establishment is an additional characteristic of ship type. A target track is updated (without error) with a detection by any radar on any ship or defense unit in communication with the ship carrying the track. A target track is dropped by a particular ship whenever a 30-second interval has elapsed during which no updates from any communicating ships were made.

^{*}D.J. Kaplan, A. Grindlay, and L. Davis, "Surveillance Radar Systems Evaluation Model (SURSEM) Handbook," NRL Report 8037, Jan. 14, 1977.

The noise energy for 2D radars is

$$N_{s}^{*} = C_{2} + C_{3} \sum_{j} (j \in G) [J_{j}G_{H}(\phi_{j} - \phi_{s}^{*})G_{V}(\theta_{j})R_{j}^{-2}]$$

and for 3D radars is

$$N_{s}^{*} = C_{2} + C_{3} \sum_{j} (j \in G) [J_{j}G_{H}(\phi_{j} - \phi_{s}^{*})G_{V}(\phi_{j} - \phi_{s}^{*})R_{j}^{-2}].$$

The signal-to-noise energy ratio is:

$$\rho_S^* = E_S^*/N_S^*.$$

Then the probability of detection P_D is calculated as a function of $^\star e_s$, the false alarm probability of the radar, and the number of pulses integrated for a detection decision. This is under the assumption of a Marcum and Swerling type-3 target.

2.3A Radar Surveillance/Radar Tracking Variant

In the revised version of SPEARS called the radar surveillance/ radar tracking variant, the shipboard-radar-surveillance function is performed by the incorporated submodel SURSEM (Surveillance Radar Systems Evaluation Model). Since SURSEM has been documented in detail,* an abbreviated description of the detection process will be given here. A surveillance radar is characterized by its radar scan modes, which define the radar's operating characteristics for the illumination of specific geometrical regions. For each active scan mode of a surveillance radar, a single-scan probability-of-detection of each active target is calculated as a function of the target's position and environment. The process takes into account the target aspect angle, target fluctuations, multipath propagation, rain and sea clutter, rain attenuation, and jamming.

^{*}D.J. Kaplan, A. Grindlay, and L. Davis, "Surveillance Radar Systems Evaluation Model (SURSEM) Handbook," NRL Report 8037, Jan. 14, 1977.

The free-space returning signal power at beam maximum from a given target is calculated according to

$$P_{r} = \frac{P_{t} G^{2} \lambda^{2} \sigma(\psi) L_{r} L_{t} L_{m}}{(4\pi)^{2} R^{4}}$$

where P_{t} is the peak power, G is the one-way antenna gain, λ is the radar wavelength, $\sigma(\psi)$ is the computed target cross section as a function of aspect angle, R is the target range, and L_{r} , L_{t} , and L_{m} are the receiver, transmitter, and mode-dependent losses respectively. The received signal energy is

$$S = P_r \tau[f(\theta)]^2 F^4 A_r [min(B_{IF}\tau_c, 1)],$$

where τ is the pulse length, $f(\theta)$ is the one-way beam-pattern factor as a function of the angular displacement of the target from beam center, F is the calculated multipath-pattern-propagation factor, A_r is the computed two-way rain attenuation factor, and B_{IF} τ_{C} is the radar's IF bandwidth multiplied by its compressed pulse length.

The total noise energy includes thermal noise, jamming energy, sea clutter, and rain backscatter. The thermal noise energy is

$$N_T = F_n k T_0$$

where F_n is the receiver noise figure, k is Boltzmann's constant, and T_0 is the system temperature. The free-space jamming energy contributed by each jamming target is

$$E_{0J} = \frac{G_r L_r L_m S_j f_{HV}^2}{(4\pi^2)R^2}$$

where ${\rm G}_{\rm r}$ is the one-way antenna gain, ${\rm L}_{\rm r}$ is the receiving antenna loss, ${\rm L}_{\rm m}$ is the mode-dependent loss, ${\rm S}_{\rm j}$ is the jamming power density, ${\rm f}_{\rm HV}$ is

the beam pattern factor, λ is the radar wavelength, and R is the slant range from the radar to the target. The jamming energy contributed by each jamming target is then modified by the appropriate one-way pattern propagation factor to account for the effects of multipath propagation, so that

$$E_{J} = E_{0J}F^{2}$$
,

and the total jamming energy is

$$E_{TJ} = \sum_{1}^{N_{J}} E_{J},$$

where N $_{\rm J}$ is the number of jamming targets. To determine the contribution of sea-clutter to the total noise energy, the normalized mean backscatter σ_0 from the sea surface is calculated as a function of radar frequency, wind velocity and the height to which it corresponds, target angle of incidence, and polarization orientation. The total sea-clutter energy is considered to be the energy that is reflected from an annulus of width ΔR , defined by

$$\Delta R = \frac{c\tau}{2} \sec(\omega)$$

where τ is the pulse length and ω is the grazing angle. Then, the total sea-clutter energy E, which can be derived by a lengthy calculation, is reduced by the radar's sea-clutter improvement factor I.

$$E_c = EI_c$$

Rain is modeled by a large number of independent scatterers, each of cross section σ_i and located within the radar resolution cell. If the raindrop diameter is assumed small in comparison to the radar's

wavelength, σ_i can be expressed in terms of drop diameter or ultimately rainfall rate, so that the total rain cross section in the resolution cell is

$$_{R}^{\sigma} = 6.706 \times 10^{-6} _{CBB}^{\tau} _{BR}^{\phi} ^{2} r^{1.6} _{\lambda}^{-4},$$

where ${}^{\tau}_{c}$ is the compressed length, ${}^{\theta}_{B}$ and ${}^{\phi}_{B}$ are the horizontal and vertical 3-dB beamwidths respectively, R is the target range, r is the rainfall rate, and λ is the radar wavelength. The rain backscatter energy is computed according to

$$E_{R} = \frac{6\sigma_{R}^{p} r^{I} c^{\tau}}{\sigma(\psi)}$$

where $\mathbf{I}_{\mathbf{C}}$ is the radar rain-clutter improvement factor. The total noise energy is

$$N = (N_T + E_{TJ}^A_{or} + E_c^A_r + E_R^A_r)^{max}(B_{IF}^{\tau}, 1),$$

where A_{or} and A_{r} are the one-way and two-way rain attentuation factors respectively, and the adjustment factor $\max(B_{IF}^{\tau}, 1)$ allows for increased noise due to an unmatched IF bandwidth. The single-scan probability of detection is then calculated according to the specified Marcum-Swerling target cross-section model as a function of the signal-energy-to-noise-energy ratio S/N, the number of pulses integrated, and the probability of false alarm.

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2.4 Characterization of a Defensive Weapon System

The specification of the battle scenario used to initiate the simulation includes a characterization of each defensive and offensive unit. The description of a defense unit includes a description of its weapon systems, each of which is modeled as consisting of a missile, a launcher, a missile magazine, and an associated missile guidance system. Although a unique association exists between launcher and missile magazine, a given missile guidance system may service a number of inidvidual launchers. To simplify bookkeeping within the simulation, a weapon component is classified by function (launcher, missile, or guidance) and by function type. For example, if seven launcher types are defined for the task force for a particular game play, the launcher configuration of any defense unit is specified simply by stating the type (from among the seven) and position of each launcher carried by the unit.

The following four sections are a description of the properties which characterize each of the four parts of a weapon system in this model. (A more complete discussion of these is found in Ref. 2.)

2.4.1 The Surface-To-Air-Missile

A SAM missile type is described by the following missile characteristics:

- minimum and maximum intercept ranges,
- performance envelope,
- time-of-flight data,
- lethality data,
- replacement cost.

2.4.1.1 Missile Intercept Range and Performance Envelope

The minimum and maximum missile intercept ranges together with the missile performance envelope define a solid of revolution about an origin, usually the position of the launcher, which may be interpreted as the set of points in space for which the probability of a SAM fired from the origin killing its assigned target is roughly the design constant. Outside this region, if a missile did intercept a target, a target kill would be unlikely. Therefore the model considers a missile for commitment to an established enemy track only when the projected point of intercept falls within the missile's performance envelope. Figure 2.4.1.1-1 illustrates a vertical-half-plane section of an example of a missile performance envelope with minimum and maximum missile intercept ranges.

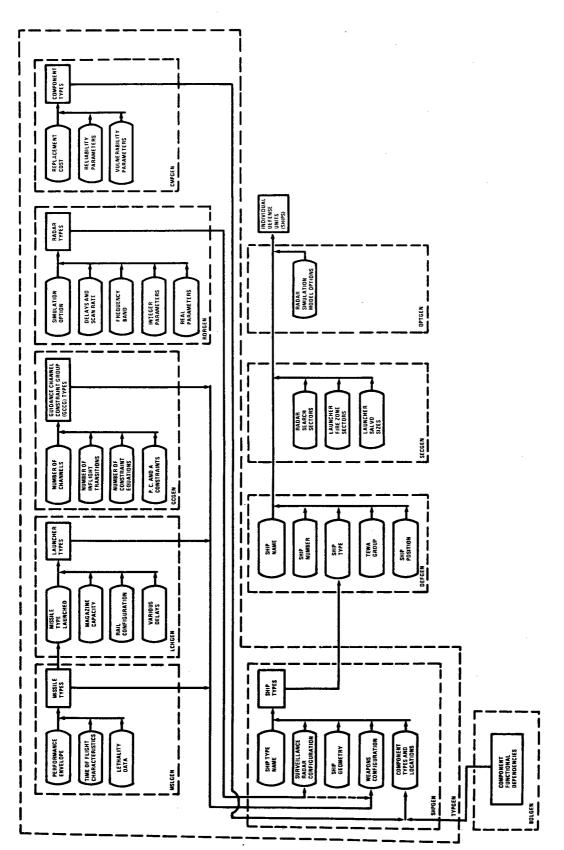


Fig. 4.4-1 - Generation of defense units

surveillance and tracking radar types (e.g., AN/SPS-48, AN/SPS-49), the surface-to-air missile types and their associated launcher systems, and the guidance channel constraint group types. The number and physical location on the hull of each such component, together with individual component vulnerability data, define the surveillance and weapons configuration of a particular ship type; the ship type may also be assigned a class name of up to 20 characters (e.g., DDG-2 CLASS or GALVESTON CLASS). Sub-routines used by TYPGEN to define surface-to-air missile types, launcher types, radar types, ship component types, guidance channel constraint group types, and ship types are MSLGEN, LCHGEN, RDRGEN, CMPGEN, GCGEN, and SHPGEN respectively; the data input formats for each of these routines are given in Appendix A together with amplifying descriptions of the various parameters involved.

The TDHS mode requires the addition of one parameter (on Card Type TS) and a new input card type. The new parameter specifies for a given ship type the number of DET/TRK operator positions available on the ship type. The new card type (Type TST) specifies the radar assignments for the TRK SUP and for each DET/TRK operator. Provision is also made on this card type to assign individual operators to automatic offset mode of operation for the track updating process.

4.4.1A

The radar surveillance/radar tracking version requires one added parameter (on Card Type TS) and a slight change in description of two parameters (on Card Types TSR and TSG). The new parameter specifies the time window during which a given target must be detected at least three times by surveillance radars on the defined ship type in order to initiate a target track. The change in description of surveillance radar types specified on Card Type TSR refers to the definition of those types now being defined by Card Types TR, TRB, and TRM. Similarly, on Card Type TSG the tracking radar type refers to a data set defined by Card Type TR only.

4.4.2 Missile Guidance Techniques

The concept of guidance channel constraint groups (Appendix G) has been introduced into the model so as to afford a single approach to simulating present-day, as well as future, missile guidance techniques. The widely used dual-simplex guidance scheme uses two fully dedicated director-illuminator tracking radar sets (or guidance channels) with each SAM launcher. A guidance channel is entirely committed to a single engagement from initial target acquisition and missile launch to intercept and kill evaluation; thereafter the guidance channel may be used to reengage the same target or to take under fire some other target, as the assignment doctrine dictates. More efficient use is made

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of the missile launcher by having it supply missiles to two guidance channels conducting independent target assignments; this is particularly true when the missile time of flight to an intercept point is large compared with the launcher cycle (or reload) time delay. A dual-simplex system may have no more than two assignments (per launcher) in progress at any given instant of time.

A somewhat different guidance scheme for more advanced missile systems abandons the notions of fully dedicated guidance channels and exclusive commitment of a guidance channel to a target throughout the course of a missile-and-target engagement. With the advanced guidance techniques a particular guidance channel may be serviced by any of several missile launchers aboard the ship, and it may divide its time among several missile-and-target engagements as the data rate requirements of each dictate. Physically the "guidance channels" in a multifunction phased array radar are more difficult to visualize than the

4.7 Specification of Defense Units

Once a library of ship types has been established in the data base, specification of individual defense units (ships and AEW aircraft) is relatively easy. Each defense unit must be defined by a single input card (of Type DF) to the Defense Generator (DEFGEN) routine. Each such DF card specifies the number, name, ship type, heading, and position (in rectangular or cylindrical coordinates) of a defense unit. Also specified is a TEWA group number for defense units having firepower capabilities; this grouping is used within the threat-evaluation procedure in the determination of the force-wide engagement status of individual targets. Inputs to the DEFGEN routine are terminated by a Type DX card; this card is also used to specify the location of the Vital Area Center used in force-wide threat-evaluation computations.

Following the DEFGEN inputs there may be additional, optional inputs to further refine the descriptions of individual defense units. These optional inputs fall into three categories; surveillance-radar search-detector definitions, launcher fire-zone sector and salvo size definitions, and radar simulation-model option selections for individual surveillance radars and guidance channel groups.

Any, all, or none of the surveillance radars aboard a defense unit (as determined by the corresponding ship type definition) may be assigned limited search sectors by use of input cards of Type SR to the Sector Generator(SECGEN) routine. Unless otherwise specified, all surveillance radars are allowed full circle coverage. Restricted search sectors are defined by giving a right-hand boundary (relative to the ship's heading or to north, as desired), and a search sector width (of from 0 to 360 degrees). Each radar is then prohibited from making target detections outside of its assigned search sector. (Individual surveillance radars may be "turned off" simply by assigning a zero-width search sector; this is an easier way to remove a radar from a ship than by going through the alternative approach of defining a different ship type.)

Fire-zone sectors for individual missiles may be defined in a similar fashion through the use of Card Type SL. Full circle coverage is again assumed unless otherwise specified. Each launcher is prohibited from launching a missile salvo against a target unless the target lies within its fire-zone sector at the time the missile assignment is made. This same card type is also used to specify the salvo size for individual launchers (the number of missiles to be fired each time as an assignment is made). A default value of one (single missile salvos) is assumed unless otherwise specified.

Only one such unit may at present be configured with surveillance radar sets in the TDHS version. Until the development of the multiple-ship TDHS model, all defense units but one must be generated from ship types having no radars or defensive weapon systems.

Several radar simulation models are available within the program, each representing a different level of detail or degree of sophistication in the treatment of the radar detection process. Which radar

simulation option(s) to use in a particular run depends on many factors, including the purpose of the run, the sensitivity of the outcome expected or previously observed as a result of the option(s) selected, and the importance attached to minimizing computer running-time costs (through the selection of simple algorithms). Each surveillance radar and each guidance channel group (tracking radar(s)) may be independently assigned the simulation model option desired. Thus a number of different radar simulation models may be employed concurrently within a given run. Unless otherwise specified, the simplest radar model is assumed (a deterministic cookie-cutter technique); this will yield the shortest possible running time, but only radar horizon, scope limit, and horizontal and vertical coverage angles will be considered in making detection decisions—effects of ECM and target cross section variations are ignored.

In the TDHS version the radar simulation algorithms no longer produce "detected" targets but rather yield an array of detectable video coordinates. A clustering routine in the MSP adjoins the video returns from closely spaced targets according to the radar resolution capabilities and other TDHS tracking parameters.

4.7A

In the radar surveillance/radar tracking version the radar detection of targets is performed by the SURSEM submodel according to the characterization of the radar as defined by its radar type, so radar simulation model options as previously defined in SPEARS no longer apply.

4.8 Specification of Offense Units

The Raid Generator (RAIDGEN) routine combines previously defined target types, ECM loading groups, and defense unit information (for targeting purposes) with flight-path and weapon-trajectory data to produce individual offense units, both impacting and nonimpacting, as diagramed in Fig. 4.5-1.

Every offense unit, or target, is associated with a piecewise linear Master Flight Path (MFP). The MFP for a nonimpacting target (e.g., launch vehicle, standoff jammer, strike-command aircraft, or cruise-missile-launching submarine) may have from two to 15 nodes (X, Y, Z). The phasing or time of departure from the first node and the speed along each flight path leg are MFP input parameters. Offense units flying in formation may be associated with a common MFP, with the lateral, axial, and vertical displacements of each from the MFP being described with the specifications of each such target. (The MFP for a nonimpacting target must be completely described as part of the run input data, and there is no variation in such flight paths between successive replications.)

Any number of nonimpacting targets may share the same basic MFP, with each such target being described by a single input card of Type RA. This card specifies the target type and ECM loading group (both previously defined by inputs to the TYPGEN routine), the displacement values (relative to the most recently defined MFP), and the number of parasites carried (if any).

virtue of scheduling an UPDATE event in the game calendar. The TRACKR event would thereupon reschedule itself, after a suitable delay-time interval representing the period during which the DET/TRK operator is occupied making the necessary console-button-pushing operations.

Should no video correlate with the sequenced track, then a missed-report event (MISSTK) is scheduled for the track and the TRACKR event reschedules itself after the time required for the radar to sweep through the entire width of the operator's zone of interest.

After a predetermined number of successive missed-track reports, a given track becomes eligible to be dropped from the TDHS by the track supervisor. On a time available basis (e.g., when there are no additional new detections to be entered) the track supervisor will schedule a drop-track event (DROPTK) for a track which no longer has correlating video available.

As the workload is lessened in the TDHS (by virtue of a succession of drop-track actions), it may be appropriate to deactivate one or more of the DET/TRK operators. This is accomplished by application of a decision threshold and, when appropriate, scheduling a SLEEP event for an operator; this will have the effect of removing the operator's next scheduled TRACKER event from the game calendar.

5.3A

In the radar surveillance/radar tracking version of the MSP, the SCAN event has been rewritten extensively to serve as the link between the SPEARS logic and the SURSEM radar-surveillance submodel. A SCAN event is now scheduled initially for each radar scan mode as appropriate by the NODE event. It reschedules itself according to the periodic scan rate of the radar scan mode it represents. The occurrence of a SCAN event corresponds to an attempt by the specified radar scan mode to detect any currently active targets within its coverage volume. A scan mode of a surveillance radar is considered "activated" whenever a SCAN event is scheduled for it in the game event calendar; an ENTER event, signifying the entrance of a target into the scan mode's coverage volume, must occur for an initial activation to take place.

The occurrence of a LEAVE event corresponds to a target's passing outside the coverage volume of the scan mode of a particular radar. A radar scan mode is deactivated when no active targets are within its coverage volume or when the radar is disabled as a result of enemy-weapon impact or system failure. The deactivation of a radar scan mode cancels any scheduled SCAN events for that scan mode. Reactivation of a radar scan mode and the scheduling of a corresponding SCAN event follows the occurrence of an appropriate ENTER event or the repair of the radar set.

A probability of detection for each active target within the coverage volume of the specified radar scan mode is calculated within the SCAN event, using the SURSEM submodel. Monte Carlo sampling is then used to determine if any detections actually take place, and DETECT events are scheduled for current game time accordingly. A primary difference between this version and the parent model is that here a radar scan mode holds a target in a detected status with no effect on the scheduling of subsequent SCAN events, since update reports are necessary for track establishment and maintenance.

The occurrence of a DETECT event for a particular radar-and-target combination initializes or updates the track history for that target as carried by the defense unit on which the radar resides. A defense unit establishes a target track when any combination of radars on the defense unit detects a given target three times within a specified time window. The defense unit drops the track if no update (detection) is recorded within a given update time period by either the defense unit's own radars or the radars of any defense unit with which it may communicate.

A PASS event is scheduled by the DETECT event to identify those defense units able to receive communication transmissions from the defense unit responsible for the detection. The detection report is then passed on to each appropriate radar by means of a PASDET event. The occurrence of a PASDET event for a particular radar-and-target pair triggers a check of the track history of the target as carried by the defense unit on which the receiving radar resides. If a track has already been established, the transmitted detection will update the track history if received within the specified update time period. Otherwise it has no effect on the track history as carried by the defense unit, since a detection received through a communication link cannot contribute toward track establishment.

5.4 Threat-Evaluaton and Weapon-Assignment Events

There are ten event types primarily associated with threat evaluation and weapon assignment: TEWA, ASSIGN, LAUNCH, INTCPT, RELEAS, TRNSFR, ABORT, DROP, COMEIN, and OUTGO. The TEWA (threat evaluation and weapon assignment) event involves several large subroutines and like event type NODE is one of the most complex event types in the simulation model. A TEWA event sequence is associated with each defense unit having SAM firepower capability. Scheduling of the initial TEWA event for a defense unit is triggered by the first detection made with respect to that defense unit; this TEWA is displaced in time from its generating DETECT event by an evaluation reaction time, the value of which is specified on the GP input data card. Thereafter the TEWA event for the defense unit regenerates itself according to a time interval either as specified on the GP input data card or as determined by the next earliest time of weapon availability.

The total number of targets within SAM assignment range of any given ship is kept by incrementing a counter by one each time a COMEIN event for a particular ship occurs (and by decrementing the counter by one each time an OUTGO event for it occurs). Whenever the in-range target counter, for a particular defense unit is incremented from 0 to 1, a TEWA event is scheduled for that ship unless there is already one in the game-event calendar.

When a TEWA event occurs, the value held in the in-range target counter for that defense unit is tested. If the value is 0, control will be returned immediately to the main program without scheduling a future TEWA event for the ship. Otherwise a preliminary check is made to determine if the specified defense unit has any weapons available for possible assignment during the current TEWA interval (between current game time and the latest time at which the next TEWA event for this defense unit will occur). If no weapons are available, due to engagements in process and/or to disablement of necessary weapon system components, the event will proceed no further but will simply reschedule itself for the earliest time at which a weapon will become available.

If one or more weapon systems are found to be available on the defense unit, then the TEWA routine will produce a threat-ordered list of the targets currently held in a detected status with respect to the defense unit using a threat-ordering algorithm patterned after the procedure used within the Naval Tactical Data System (NTDS). Threat ordering is done with respect to both own ship and the task force Vital Area Center. Preference is given to self-defense, and then to area defense, with threat-number ties being broken by random-number selection.

Offense units found to have sufficiently high threat numbers are then considered for possible engagement by SAM weapons. The weapon assignment routine verifies availability of the necessary weapon-system components, performs a trial intercept calculation, determines if the predicted intercept point lies within the performance envelope of the missile type being considered, and checks the guidance channel constraint expressions to insure that they are satisfied throughout the expected duration of the assignment. If more than one SAM system aboard the defense unit is capable of engaging the designated target, preference will be given in the following order:

- 1. To the system having the higher priority missile type, where missile priority is inversely related to maximum range capability (reflecting missile replacement costs),
- 2. To the system able to achieve the earliest assignment time within the current TEWA interval, and finally,
- 3. To the system having the greatest number of missiles remaining in its launcher magazine.

Once a SAM system has been selected for the assignment, an ASSIGN event will be scheduled in the game calendar, and if weapons are still available on the defense unit, another target will be considered for possible engagement. This process will continue until there are no more engageable targets or no more weapons available on the defense unit.

The ASSIGN event indicates the pairing of a weapon and a target as determined in the TEWA process. The corresponding LAUNCH event is then scheduled for a time displaced from the ASSIGN time by the target acquisition delay of the guidance system and the firing circuit activation delay of the selected missile launcher.

Occurrence of a LAUNCH event corresponds to the firing of a SAM from its launcher. The computed time of flight to the predicted intercept point is then used to schedule the subsequent INTCPT event.

When the INTCPT event occurs, a Monte Carlo evaluation is made to determine if the missile succeeded in inflicting lethal damage to its assigned target. If so, a second random sampling is made to establish the time required for the target to die (to become ineffective and eligible for removal from the play of the game) and a DIE event for the target is scheduled accordingly. If the time of death so computed is earlier than any previously held time of death for that target, then the later DIE event is removed from the game calendar. At this point the SAM system is tentatively given credit for killing the target.

The INTCPT event also causes scheduling of a RELEAS event for the SAM system at a later time, following the kill-evaluation delay period associated with the weapon type used. Occurrence of the RELEAS event simply releases the weapon system from its most recent engagement, making it available for a new assignment.

However not all SAM engagements can be expected to go smoothly from the ASSIGN to the RELEAS event. Some of the possible causes for disruption of the normal sequence of events in the history of a SAM engagement are:

- The target may change its course in such a manner that interception by the assigned missile is no longer possible due either to performance-envelope restrictions or to violation of the guidance-channel-constraint expressions;
- The target may be killed by another missile system (target preemption);
- The target may cease to exist, by reaching its final flightpath node (this will normally only happen for impacting target types);

 One or more necessary components of the SAM system may be disabled due to the effects of an enemy weapon impact.

Depending on the nature of the disruption, the time at which it occurs (relative to the predicted SAM engagement history), and the availability of other nearby (indistinguishable) targets, the SAM engagement may be dropped, transferred, aborted, or simply released.

A DROP event will be scheduled if the assignment cannot be completed and if the missile (salvo) has not been irrevocably committed to the engagement. Thus, if the launcher firing circuit has not yet been activated, the assignment will be scratched with no missile expenditure.

If the SAM engagement in question has already achieved its intercept, then the disruption will have little effect on that assignment except that the weapon system release may be scheduled for a slightly earlier time.

A TRNSFR event will be scheduled if the launcher has been fired (but target interception has not yet occurred), and there is available another target to which the assignment may be transferred. The rules by which eligibility for transfer is decided are under control of the programmer so they may be made prohibitive (no transfers allowed), restrictive (transfer allowed to another target occupying the same radar resolution cell as the original target), or permissive (according to virtually any other criteria desired). After a TRNSFR event the remaining engagement events (e.g., INTCPT, RELEAS) will proceed as if the assignment had been originally made to the new target except that they may be rescheduled to reflect a different intercept time.

If the missile has been irrevocably committed to the engagement and transfer to another target is not possible (or allowed), then an ABORT event will be scheduled which will terminate the engagement with the unproductive expenditure of the missile salvo.

This area of the simulation model is currently deactivated in the TDHS version. To bring the TEWA functions into the TDHS SPEARS, it will be necessary to key those functions to track-history data rather than to actual target-position data as is done in the parent model.

5.4A

The radar surveillance/radar tracking version of SPEARS employs the threat-evaluation and weapon-assignment events of its parent model with the replacement of "detection" by "established track". Scheduling of the initial TEWA event for a defense unit is now triggered by the establishment of the first target track by that defense unit. Within TEWA a threat-ordered list of all targets for which the defense unit

carries a current established track is made for potential weapon assignment. An established track is considered current by TEWA if it has been updated within a specified update time period; established tracks carried by the defense unit found not current by TEWA are dropped.

5.5 Attrition of Offense Events

There are two event types primarily related to kill, damage, and disablement of offense units: DIE and VICTIM. Both event types relate to the attrition of offense units through the effects of defensive missile firepower and result from the occurrence of an INTCPT event.

Scheduling of a DIE event for a target results from one or more successful intercepts by defensive missile firepower, as previously discussed. If the target has reached its final flight-path node (with a VANISH or IMPACT event) prior to occurrence of the DIE event, then no further action is taken since the target would have been already removed from the game play. Otherwise the target is tagged as being "dead" and the SAM system responsible for the DIE event is credited with a target kill. The target is then removed from the game plan in much the same manner as in the VANISH and IMPACT events. In addition any unlaunched parasites or in-flight targets dependent on the killed target for guidance signals will be attrited through the use of a VICTIM event type scheduled concurrently with the DIE event (at current game time).

Occurrence of a VICTIM event for an unlaunched parasite involves nothing more than tagging the target as dead and crediting the responsible SAM system with an additional target kill. If the VICTIM event

(This page blank)

| | FORMAT | LABEL | PLANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|--------|---------|------------------------|---------|---|---|--|------------------|-------------------|
| 11 2 3 | ТR | | | | Label | N/A | 1 2 3 4 5 | FORMAT NUMBER | CARD |
| 4. | (12) | | | | (Unused integer) | N/A | 4 5 | 7 | ᇕᅵ |
| <u> 6 7 8 9 10 11 12 13 14 15 16 17 16 19 20 21 22 23 24 25 28 27 28 29 30 31 32 33 34 33 35 37 38 38 40 41 42 43 44 46 48 47 48 48 65 18 25 53 54 55</u> | (20H) | (ACARD) | (Alpha) | | Radar-type name | RDRTNM (I,NRDR), I=1,N2OBCD | 3 | 1 READING TYPGEN | PURPOSE Rada |
| 19 20 21 22 23 24 25 26 | | 7 | NF. | fir | | | 16 17 18 19 20 21 22 23 24 25 26 | | Radar-type header |
| 27 28 29 30 | (15) | NRDR | 1 to NRTMAX | nteger | Radar-type number | N/A | 27 28 29 303 | USING ROUTINE | |
| E PE CE ZE IE | (15) | | l or 2 only | integer | Type of radar | IRDRPC (NRDR) | 1 32 33 34 35 | RDRGEN | |
| 36 37 36 30 4 | (15) | | | | Radar frequency (surveillance radars) or target acquisition delay time (for fire-control radars) | RBPAR (1,NRDR) or IRDRPCd (NRDR) | 36 37 38 39 40 | | |
| 41 42 43 44 46 | (15) | | | | Antenna pattern indicator (for surveillance radars) or kill evaluation delay time (for fire- control radars) | RBPAR (2,NRDR) or IRDRPC (NRDR) ^e | 41 42 43 44 45 | | |
| 46 47 48 49 50 | (15) | | 0 to 90 | degrees | Linear polarization (for surveillance radars only) | RBPAR (10,NRDR) | 48 47 48 48 50 | | |
| | (15) | | 1 to 15 | | No of radar scan modes (for surveillance radars only) | IRDRPC (NRDR) | 51 52 53 54 56 | | |
| 56 57 58 69 50 | (15) | | | | | | 6 57 56 59 60 | | |
| 81 62 63 64 66 | (15) | | | | | | 61 62 63 64 65 | | |
| 16 67 68 60 70 | (15) | | | | | | 36 67 68 69 70 | | PAGE |
| 56 57 56 69 50 51 62 63 64 86 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 66 67 68 69 70 /1 /2 /3 /4 /5 /6 /7 /8 /9 80 | | ا ا و |
| P6 77 78 79 BO | (5X) | | | | (Sequence field) | N/A | 76 77 78 79 80 | | 5 |

Amplification of Card Type TR (For the radar surveillance/radar tracking version only)

This version of Card Type TR and Card Types TRB and TRM which follow replace the original Card Types TR, TRI, and TRF in the radar surveillance/radar tracking version of SPEARS.

| Card Columns | Description |
|--------------|---|
| 1-2 | The label TR indicating that this card is a radar-type header. |
| 6-25 | Twenty-character field which may be used to assign a name to this radar type. |
| 26-30 | Identification number (NRDR) for this type. |
| 31-35 | Type of radar (1 = surveillance, 2 = tracking/fire control). |
| 36-40 | For surveillance radars: radar frequency in megahertz. For tracking/fire control radars: target acquisition delay time. This delay represents the mean time from assignment of a firecontrol radar to a target to the acquisition of the target by the radar (0 to 31 s). |
| 41-45 | For surveillance radars: antenna pattern indicator (0 = pencil beam, 1 = cosecant squared beam). |
| | For tracking/fire control radars: kill evaluation delay time. This delay represents the mean time from intercept of a target to the assessment of the intercept (0 to 31 s). |
| 46-50 | Linear polarization in degrees, from 0 to 90, where 0° = horizontal and 90° = vertical. |
| 51-55 | Number of radar scan modes (limited to 15). |

(Fields 46-50 and 51-55 are ignored for tracking/fire-control radars).

| | FORMAT | LABEL | RANGE OF WALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|-----------------------|---------|--|---------------|--|-------------------|-------------------------|
| 11 2 3 | TRB | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| | (12) | | | | (Unused integer) | N/A | \$ | 35 | 1 |
| 4 5 6 7 8 9 10 11 12 13 14 | | | | dB | Receiver noise | RBPAR(3,NRDR) | | 2 READING ROUTINE | TRB |
| 8 9 10 11 12 13 14 15 16 17 18 18 20 21 22 23 24 25 26 27 28 27 30 31 31 31 31 31 31 31 31 31 31 31 34 44 44 44 44 44 47 44 48 48 18 18 18 18 18 18 18 18 18 18 18 18 18 | (F10.3) | | | degrees | Horizontal 3-dB beamwidth | RBPAR(4,NRDR) | 16 17 18 19 20 21 22 23 24 25 | | Surveillance-radar-type |
| 26 27 26 29 3031 32 33 34 35 | (F10.3) | | | degrees | Vertical 3-dB beamwidth | RBPAR(5,NRDR) | 26 27 28 29 30 31 32 33 34 35 | NSING RDRGEN | |
| 36 37 38 39 40/41 42 43 44 4 | (F10.3) | | | dB | One-way antenna gain | RBPAR(6,NRDR) | 31 32 33 34 35 36 37 38 39 40 41 42 43 46 45 46 47 48 49 50 61 52 53 54 55 | N REMARKS | basic parameters |
| 46 47 46 49 50 51 52 53 54 55 | (F10.3) | | | dB | One-way sidelobe level down from peak | RBPAR(7,NRDR) | 46 47 48 49 500 152 53 54 55 | | |
| | | | | dB | Receiver line loss | RBPAR(8,NRDR | 36 5/ 36 39 6061 6/ 63 64 63 6 | | |
| 59 50 61 62 63 64 60 66 67 66 69 7071 72 73 74 76 76 77 78 79 80 | (F10.3) | | | dB | Transmitter line loss | RBPAR(9,NRDR | 9 67 68 69 74 71 72 13 14 75 | | PAGE 2 OF |
| 70 77 70 79 80 | (5X) | | | | | | 0 // /0 / 3 80 | | ហ |

Amplification of Card Type TRB (For the radar surveillance/radar tracking version only)

| Card Columns | <u>Description</u> |
|--------------|--|
| 1-3 | The label TRB indicating that this card contains seven basic radar parameters (in addition to those on card type TR) for surveillance radars only. |
| 6-15 | Receiver noise in dB, |
| 16-25 | Horizontal 3-dB beamwidth in degrees. |
| 26-35 | Vertical 3-dB beamwidth in degrees. |
| 36-45 | One-way antenna gain in dB. |
| 46-55 | One-way sidelobe level in dB down. |
| 56-65 | Receiver line loss in dB. |
| 66-75 | Transmitter line loss in dB. |

| | FORMAT | LABEL | PANGE OF WILUES | STINO | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|-----------------------|--------------|---|---------------------|--|----------------|--------------------------------|
| 1 2 3 | | | | | Label | N/A | 123 | NUMBER | CARD |
| = | (12) | | | | (Unused integer) | N/A | 5 | E A | |
| ~ | l | | | degrees | Lower limit of elevation-angle coverage | RMPAR (1,J,NRDR) | 6 7 8 9 101112131 | 2 READING | TRM |
| 8 9 10 11 12 13 14 19 18 17 18 18 20 21 22 23 24 25 28 27 28 28 30(3) 32 33 34 38 37 38 38 40 41 42 43 44 48 48 47 48 48 10 18 132 53 64 55 66 57 56 | (F10.3) | | | degrees | Upper limit of elevation-angle coverage | RMPAR (2,J,NRDR) | 15 16 17 18 19 20 21 22 23 24 25 | RDRGEN | |
| 26 27 28 29 2021 22 33 34 35 | (F10.3) | | | megawatts | Peak power | RMPAR (3,J,NRDR) | 30 31 32 33 34 35 | ROUTINE RDRGEN | Surveillance-radar-type mode p |
| 36 37 38 38 4041 42 43 44 46 | (F10.3) | | | microseconds | Pulse length | RMPAR (4,J,NRDR) | 36 37 38 39 40 41 42 43 44 45 | N HEMARKS | parameters - first |
| 40 47 40 49 50 51 52 53 54 55 | (F10.3) | | | seconds | Interlook period (time between scans) | RMPAR (5,J,NRDR) | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | card |
| | (F10.3) | | | seconds | Scan offset (relative to radar initialization) | RMPAR (6,J,NRDR) | 56 57 50 59 60 61 62 63 64 65 6 | | |
| 19 90 61 62 63 64 66 66 67 66 69 7071 72 73 74 76 76 77 78 79 80 | (F10.3) | | | naut. miles | Instrumented range | RMPAR (7,J,NRDR) | 9 60 61 62 63 64 65 66 67 68 69 70 71 12 13 14 15 78 17 18 19 80 | | PAGE 3 OF |
| 76 77 78 79 80 | (5X) | | | | | | 16 77 78 79 80 | | თ |

Amplification of the First Card of Card Type TRM (For the radar surveillance/radar tracking version only)

| Card Columns | <u>Description</u> |
|--------------|--|
| 1-3 | The label TRM indicating that this card contains surveillance-radar scan-mode parameters. Three cards, each labeled TRM, are required for each radar scan mode, which are numbered by SPEARS in ascending order as they are defined, beginning with 1. |
| 6-15 | Lower limit of elevation-angle coverage in degrees. |
| 16-25 | Upper limit of elevation-angle coverage in degrees. |
| 26-35 | Peak power in megawatts. |
| 36-45 | Pulse length in microseconds. |
| 46-55 | Interlook period (time between scans) in seconds. |
| 56-65 | Scan offset (relative to radar initialization) in seconds. |
| 66-75 | Instrumented range in nautical miles. |

| | FORMAT | LABEL | NALUES OF | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|--------------|--------------|--|----------------------|---|----------------|---|
| 1 2 3 | TRM | | | | Label | N/A | = = = | HARWON I | CARU |
| 5 | (12) | L | <u>L</u> | | (Unused integer) | N/A | |]== | |
| 6 7 0 9 10 11 12 13 14 15 | (F10.3) | | | dВ | Mode-dependent loss | RMPAR (8,J,NRDR) | 6 1 8 9 idir 12 13 14 15 | 2 READING | TRM |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 21 22 33 34 35 17 38 39 30 41 42 43 44 46 46 47 48 49 50 81 82 53 54 85 162 57 58 | (F10.3) | | | | Number of pulses integrated | RMPAR (9,J,NRDR) | 16 17 18 19 20 21 72 23 24 25 | RDRGEN | Surveillance-r |
| 26 17 28 29 3G31 32 33 M 35 | (F10.3) | | | | Minus log ₁₀ (false-alarm probability) | RMPAR (10,J,NRDR) | 26 21 28 29 3d 31 32 33 34 35 | HOUTINE RDRGEN | Surveillance-radar-type mode parameters |
| 36 37 36 39 4041 42 43 44 46 | (F10.3) | | | microseconds | Compressed pulse length | RMPAR (11,J,NRDR) | 55 PS CS 25 18 05 64 89 48 94 58 PP CP 28 18 D1 6C 8C 4C 9C | 2 | rameters - second |
| 46 47 46 49 50 51 52 53 54 55 | (F10.3) | | | dВ | Sea-clutter improvement factor | RMPAR (12,J,NRDR) | 16 47 48 49 50 51 52 53 54 55 | | card |
| | (F10.3) | | | megahertz | Intermediate-frequency bandwidth | RMPAR (13,J,NRDR) | 56 57 58 59 60 61 62 63 64 65 | | |
| 59 54 61 82 63 64 65 66 87 68 69 70/11 72 73 74 75 78 77 78 79 80 | (F]0_3) | | | megahertz | Mode dependent frequency increment | RMPAR (14,J,NRDR) | 59 60 61 62 63 64 65 66 61 68 69 70 11 12 13 14 15 16 11 18 19 80 | | PAGE OF |
| 78 77 78 79 BG | (XS) | | | | | | 76 77 78 79 80 | | σ ⁻ |

Amplification of the Second Card of Card Type TRM (For the radar surveillance/radar tracking version only)

| Card Columns | <u>Description</u> |
|--------------|---|
| 1-3 | The label TRM. |
| 6-15 | Mode-dependent loss in dB. |
| 16-25 | Number of pulses integrated. |
| 26-35 | Minus log_{10} (false-alarm probability). (For example, if the false-alarm probability is 10^{-6} , it would be entered as 6.) |
| 36-45 | Compressed-pulse length in microseconds. |
| 46-55 | Sea-clutter improvement factor in dB. |
| 56-65 | Intermediate-frequency bandwidth in megahertz. (If 0 is entered, the bandwidth is set at the reciprocal of the compressed pulse length.) |
| 66-75 | Mode-dependent frequency increment in megahertz. (A nonzero entry affects the horizontal and vertical beamwidth and antenna gain for this scan mode.) |

| | FORMAT | LABEL | OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|---|---------|-------|--------------|--------------|------------------------------------|----------------------|--|------------------|---|
| 1 2 3 | 콗 | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 5 | (12) | | | | (Unused integer) | N/A | 5 | 33 | 1 |
| 6 7 0 9 10 11 12 13 14 15 | (F10.3) | | | microseconds | Blanking time | RMPAR (15,J,NRDR) | 6 7 8 9 10 11 12 13 14 15 | 2 READING | TRM |
| 16 17 18 19 20 21 22 23 24 25 | (F10.3) | | | dB | Rain-clutter improvement factor | RMPAR (16,J,NRDR) | 6 17 18 19 20 21 27 23 24 25 | RDRGEN | |
| 26 27 28 29 30[3] 32 33 34 3 | (F10.3) | | | | | | 26 21 28 29 30 | RD RD | Surveillance-radar-type mode parameters |
| 5 36 37 38 39 4041 42 43 44 4 | | | | | | | 36 37 38 39 40 43 42 43 44 | RDRGEN REMARKS | e parameters - th |
| 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 27 26 27 28 27 26 27 28 27 26 27 28 27 | | | | | | | 31 32 33 34 39 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | - third card |
| 56 57 56 69 50 61 62 63 64 60 64 | | | | | | | 56 57 50 59 60 61 62 63 64 65 6 | | |
| 197 66 68 7071 72 73 74 75 | | | | | | | 59 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE 5 OF |
| 977787880 | (5X) | | | | | | 5 77 78 79 BO | | 5 |

Amplification of the Third Card of Card Type TRM (For the radar surveillance/radar tracking version only)

| Card Columns | Description |
|--------------|---|
| 1-3 | The label TRM. |
| 6-15 | Blanking time in microseconds. (A zero entry sets the blanking time at the pulse length.) |
| 16-25 | Rain-clutter improvement factor in dB. |

| | FORMAT | LOCAL | RANGE OF VALUES | STINU | DESCRIPTION | DISPOSITION | | | |
|--|--------|---------|-----------------------|---------|--|-----------------------------------|--|----------------|--|
| - | AT T | - F | SS E | s | | | -12 | z 'n | zol |
| 2 3 | G | | | | Label | N/A | 2 3 4 | FORMAT | CARD |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 5 | ב ב | ۱, |
| 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20Н) | (ACARD) | (Alpha) | | Guidance Channel Constraint Group Type name | GCGTNM (I,NGCG), I=1,N20BCD | 7 8 9 1011 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | READING TYPGEN | 7G PURPOSE Guidance Channel Constraint Group Type Header |
| 26 27 28 29 30 | (15) | NGCG | 1 to | integer | Guidance Channel Constraint Group Type number | n/A | 26 27 28 29 30 | USING | nstraint (|
| 31 32 33 34 35 | (15) | NC | 1 to 31 | integer | Total number of Guidance Channels associated with this Constraint Group Type | NGCTYP (NGCG) | 31 32 33 34 35 | GCGEN | Group Type |
| 36 37 38 39 40 | (15) | NT | 0 to 7 | integer | Number of Inflight Transitions associated with this Constraint Group Type | NGCTYP (NGCG) | 36 37 38 39 40 | | Header |
| 41 42 43 44 45 | (15) | NR | 1 to 8 | integer | Number of Constraint Equations associated with this Constraint Group Type | NGCTYP (NGCG) ^e | 11 42 43 44 45 | REMARKS | |
| 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (15) | | | | | | 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | | |
| 51 52 53 54 55 | (15) | | | | | | 51 52 53 54 55 | | |
| | | | | | | | 5 | | |
| 61 62 63 64 65 | (15) | | | | | | 58 59 60 61 62 63 64 65 | | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 66 67 68 69 70 71 72 73 74 75 | | PAGE |
| 11 72 73 74 75 | (15) | | | | | | 71 72 73 74 75 | | 1 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | .4 |

Amplification of Card Type TE

| Card Columns | Description | | | | | |
|--------------|---|--|--|--|--|--|
| 1-2 | The label "TE" indicates that this is an ECM Loading Group card. | | | | | |
| 26-30 | The identification number of the ECM Loading Group data that follows. It may be used as a reference number when generating targets (aircraft and missiles). | | | | | |
| 31-35 | Communications band jamming indicator where 1 indicates that this is a jamming group and 0 (or blank) that it is not. | | | | | |
| 36-40 | P-Band power density given in w/mHz. | | | | | |
| 41-45 | L-Band power density given in w/mHz. | | | | | |
| 46-50 | S-Band power density given in w/mHz. | | | | | |
| 51-55 | C-Band power density given in w/mHz. | | | | | |
| 56-60 | X-Band power density given in w/mHz. | | | | | |

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|---------|---|-----------------------------|---|------------------|---------------------------------|
| 1 2 3 | 10 | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | П | (Unused integer) | N/A | 5 | ٣A | |
| 6 7 8 | | | | | | | 6 7 8 9 101 | 1 P | TC |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | (20н) | | | | (Not used) | | 10 11 12 13 14 15 16 17 18 19 20 | READING TYPGEN | PURPOSE Cros |
| 21 22 23 24 25 21 | | | N | j | | | 16 17 18 19 20 21 22 23 24 25 26 | | Cross-section group-header card |
| 27 28 29 30 | (15) | NG | 1 to | integer | Cross-section group-index value | N/A | 27 28 29 30 | SING OUTINE | group-h |
| 31 32 33 34 36 | (15) | M | 1,2,or 3 | integer | Option number | NCSGRP (NG) c | 31 32 33 34 35 | ROUTINE CSGEN | eader ca |
| 26 27 26 29 30 31 32 33 34 36 36 37 38 39 40 41 42 43 44 46 46 47 48 49 80 | (15) | NI | l to 7 only | integer | Number of rows in cross-section data to follow | NCSGRP _d (NG) | 36 37 36 39 40 41 42 43 44 45 46 47 48 49 60 | | rd |
| 41 42 43 44 46 | (15) | Ŋ | l to 7 only | integer | Number of columns in cross-section data to follow | NCSGRP (NG) e | 11 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | 0 to 4 only | integer | Marcum-Swerling cross-section model number | NCSGRP (NG) f | 46 47 48 49 50 | | |
| 51 52 53 54 55 56 57 58 59 50 | (15) | | | | | | 51 52 53 54 55 | | |
| | (15) | | | | | | 56 57 56 59 60 | | |
| 11 62 63 64 66 | (15) | | | | | | 1 62 63 64 65 | | |
| 61 62 63 64 00 06 67 66 69 70 71 72 73 74 75 74 77 78 78 80 | (15) | | | | | | 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | PAGE |
| 172 73 74 75 | (15) | | | | | | 71 72 73 74 750 | | l of |
| N 77 78 7980 | (5X) | | | | (Sequence field) | N/A | 76 77 78 79 80 | | 2 |

Amplification of Card Type TC

| Card Columns | Description |
|--------------|---|
| 1-2 | The label TC indicating that this is a cross section group-header card. |
| 26-30 | The identification number, NG, of the cross- section group data that follow. This value may be used as a reference number in describ- ing a target type on Card Type TT. |
| 31-35 | Option number for radar cross-section data. The available options are: |
| | Option 1: $\sigma(I,M) = A(I,1,M)$, |
| | Option 2: $\sigma(I, \Phi, M) = \sum_{j=1}^{NJ} [A(I,j,M) \Phi^{j-1}],$ |
| | Option 3: $\sigma(\Phi_H, \Phi_V, M) = \sum_{i=1}^{NI} \sum_{j=1}^{NJ} A(i,j,M) \Phi_H^{i-1} \Phi_V^{j-1},$ |
| | Option 4*: $\sigma(\Phi,M) = A'(1,1,M) \cos 2\Phi + A'(2,1,M) \cos 4\Phi + A'(3,1,M) \cos 8\Phi + A'(4,1,M),$ |
| | where |
| | σ = the radar cross-section value computed for the target being considered, |
| | <pre>I = the radar frequency-band index,</pre> |
| | <pre>M = the cross-section group to which the tar- get belongs (=NG),</pre> |

 $^{{\}tt *Defined}$ for the radar surveillance/radar tracking version only.

Amplification of Card Type TC (Concluded)

| Card Columns | Description |
|--------------|--|
| | A = the cross-section data array, |
| | $_{\Phi}$ = the solid aspect angle of the target with respect to the radar position, |
| | Φ_{H} = the horizontal aspect angle, |
| | Φ_{V} = the vertical aspect angle, |
| | A' = coefficients calculated as a function of the target head-on, broadside, and minimum radar cross sections. |
| | The cross-section values computed with options 3 and 4 are independent of the radar frequency band. |
| 36-40 | Number of rows NI in cross-section data to be specified on Card Type TCD (=3 for option 4). |
| 41-45 | Number of columns NJ in cross-section data to be specified on Card Type TCD. If option 1 or 4 is given on columns 31-35 of this card, the value of this field is assumed to be 1. |
| 46-50 | Marcum-Swerling cross-section model number (0,1,2,3, or 4). |

Amplification of Card Type TCD

Repeat as many cards of this type (up to seven cards) as is necessary to describe the cross-section data array. Each card must have the letters TCD in columns 1-3.

If option 1 or 4 is selected on card type TC, only one card is necessary to list the single column of cross-section data for this group. For option 4 (defined for the radar surveillance/radar tracking version only) the entries represent:

| Card Columns | Description |
|--------------|--|
| 6-15 | Target head-on radar reflective area in m ² . |
| 16-25 | Target broadside radar reflective area in m^2 . |
| 26-35 | Target minimum radar reflective area in m ² . |

| | FORMAT | LABEL | OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | | |
|--|--------|---------|----------------|---------|--|----------------------------------|----------------------------------|--------------------|--------------|--|
| 1 2 | SI. | , | | | Label | N/A | 2 | FORMAT NUMBER | CARD | |
| 1 6 5 | (12) | | | | (Unused integer) | N/A | 5 | AAT BER | | |
| 6 7 8 9 10 | | , | | | | | 67891 | 1. | ST | |
| 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 28 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 | (2011) | (ACARD) | (Alpha) | | Ship-type name | SHPTNM (I,NST), I=1,N2OBCD | 10 11 12 13 14 15 16 17 1 | READING ROUTINE | PURPOSE | |
| 8 19 20 21 22 23 24 25 | | | · | | | | 8 19 20 21 22 23 24 25 | READING TYPGEN | Ship type he | |
| 26 27 28 29 30 | (15) | NST | 1 to NSTMAX | integer | Ship-type index value | N/A | 26 27 28 29 30 | HOUTINE | header card | |
| 31 32 33 34 35 | (15) | NR | 0 to 7 | integer | Number of scanning radar sets on ship type NST | NSHPT (NST) ^C | 31 32 33 34 35 36 37 38 39 40 | | ď. | |
| 36 37 38 39 40 | (15) | NG . | 0 to 7 | | Number of guidance-channel groups on ship type NST | NPSHPT _d (NST) | 36 37 38 39 40 | SHPGEN | | |
| 41 42 43 44 45 | (15) | NC | 0 to 63 | jer | Total number of guidance channels on ship type NST | NPSHPT (NST) e | 41 42 43 44 45 | REMARKS | | |
| 46 47 48 49 50 | (15) | N. | 0 to 15 | integer | Total number of missile launchers on ship type NST | NPSHPT (NST) | 46 47 48 49 50 51 52 53 54 | | | |
| 51 57 53 54 55 <mark> 56 57 58 59 50</mark> 61 67 63 64 65 66 67 68 69 7 0 71 72 73 74 75 76 77 78 7980 | (15) | | | integer | Number of Tracking Operators on Ship Type NST (for TDHS version only) or time window for track establishment (for radar surveil- lance/radar tracking version only | TKESTM(NST) | 51 52 53 54 55 56 57 58 59 60 61 | | | |
| 61 62 63 64 65 | (15) | | | | | · | 62 63 64 65 | | | |
| 36 67 68 69 707 | (15) | | | | | | 66 67 68 69 70 7 | | PAGE | |
| 1 72 73 74 75 | (15) | | | | | | 151 76 51 11 | | ا 1 و | |
| 16 77 78 7980 | (5X) | | | | (Sequence field) | N/A | 76 77 78 79 80 | | 5 | |

$\label{lem:linear_amplification} \mbox{Amplification of Card Type TS}$

| Card Columns | Description |
|--------------|--|
| 1-2 | The label TS indicating that this is a ship- type header card. |
| 6-25 | Twenty-character field which may be used to assign a name to the ship type being defined. |
| 26-30 | The identification number for this ship type. |
| 31-35 | The number of scanning radar sets on this ship type. Each set will be assigned a radar type on Card Type TSR. |
| 36-40 | The number of guidance channel groups on this ship type. Data for each group are described on Card Type TSG. |
| 41-45 | The total number of guidance channels on this ship type. Each guidance channel group has associated with it one or more guidance channels. The sum of guidance channels over all such groups (columns 36-40) must agree with the value of this field. |
| 46-50 | The total number of missile launchers on this ship type. Each guidance-channel group services one or more launchers. The sum of launchers over all such groups must agree with the value of this field. |
| 51-55 | The number of tracking operators aboard this ship type (for the TDHS version only), or the time window for track establishment for radars on this ship type, with three detections being required within the time specified to establish a track (for the radar surveillance/radar tracking version only). |

| | FORMAT | LABEL | RANGE OF VALUES | STIND | DESCRIPTION | DISPOSITION | | | |
|--|--------|----------------|-----------------------|---------|--|------------------------------|---|--------------------|-------------------------------|
| 1 2 3 | TSR | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD NAME |
| 4 5 | (I 2) | | | | (Unused Integer) | N/A | 4 5 | | _ |
| 6 7 8 9 10 | (15) | INTARY (1) | 1 to 31 | integer | Radar Type of the 1st Surveillance Radar Set for Ship Type NST | KRSHPT _a (NST) | 6 7 8 9 10 | 3 | TSR |
| 11 12 13 14 15 | (15) | • | • | | • | | Ιō | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | INTARY (NR) | 1 to 31 | integer | Radar Type of the NRth Surveillance Radar Set for Ship Type NST | KRSHPT * (NST) | 16 | SHPGEN | Search Rad |
| 21 22 23 24 25 | (15) | | | | | | 17 18 19 20 21 22 23 24 25 | | ar Config |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 66 | (15) | | | | | | 26 27 28 29 30 31 32 33 34 35 36 | USING ROUTINE | Search Radar Configuration of |
| 31 32 33 34 35 | (15) | | | | | | 31 32 33 34 35 | SHPGEN | Ship Type NST |
| 36 37 38 39 40 | (15) | | | | | | 36 37 38 39 40 | | e NST |
| 41 42 43 44 45 | (15) | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 34 55 | (3.1) | · | | | | | 51 52 53 54 55 | | |
| 56 57 58 59 50 | (15) | | | | | | 56 57 58 59 60 | No TSR Card | |
| 5162 63 64 65 6 | (15) | | | | | | 51 62 63 64 65 | Card if NR | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | = 0 | PAGE |
| 1 72 73 74 75 | (15) | | | | | | 7172737475 | | 2 OF |
| 76 77 78 79 80 | (5X) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | 4. |

Amplification of Card Type TSR

This card is necessary if the number of scanning radars specified on Card Type TS is nonzero. Columns 1-3 contain the letters TSR. Each scanning radar is assigned a radar type that has previously been defined by Card Types TR, TRI, and TRF, (or by Card Types TR, TRB, and TRM for the radar surveillance/radar tracking version). Up to seven scanning radar sets per ship type are allowable.

| | FORMAT | LOCAL | RANGE OF VALUES | UNITS | DESCRIPTION | DISPOSITION | | | |
|--|--------|-------|-----------------------|---------|--|------------------------------|---|----------------------|---------------|
| 1 2 3 | TSG | | | | Label | N/A | 123 | FORMAT NUMBER | CARD NAME |
| 4 5 | (12) | | | | (Unused Integer) | N/A | 4 5 | RAT | |
| 6 7 | (15) | | 1 to NRTMAX | integer | Tracking Radar Type for the 1st Guidance Channel Group for Ship Type NST | MNSHPT _a (NST) | 6 7 8 9 10 | 3 | TSG |
| 11 12 13 14 15 | (15) | i | 1 to NGCTMX | integer | Guidance Channel Constraint Group Type for the 1st Guidance Channel Group for Ship Type NST | MNSHPT _b (NST) | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 20 | (15) | NLCHT | 1 to 3 only | integer | Number of Launcher Types serviced by the 1st Guidance Channel Group for Ship Type NST | MNSHPT (NST) | 16 17 18 19 20 | SHPGEN | Weapons C |
| 21 22 23 24 25 | (15) | | l to 15 only | integer | $\mathtt{M_{11}}$, the 1st Launcher Type serviced by the 1st G.C. Group | MNSHPT _d (NST) | 21 22 23 24 25 | | Configuration |
| 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 51 | (15) | | 1 to 7 only | integer | $ m N_{11}$, the number of launchers of Type $ m M_{11}$ serviced by the 1st G.C. Group | MNSHPT _e (NST) | 26 27 28 29 30 | USING ROUTINE | ion of Ship |
| 31 32 33 34 35 | (15) | • | • | | • | • | 31 32 33 34 35 | SHPGEN | p Type NS |
| 36 37 38 39 40 | (15) | | 1 to 15 only | | M _{NLCHT,1} , the NLCHTth Launcher Type | mnshpt _* (nst) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | 1 to 7 only | | $N_{ m NLCHT,1}$, the number of launchers of type $M_{ m NLCHT,1}$ | Mnshpt _* (nst) | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | 46 47 48 49 50 | | |
| 51 52 53 54 55 | (15) | | | | (Only one Guidance Channel Group is described on each "TSG" card. Use additional cards of similar format as required to describe all 'NG" | | 51 52 53 54 55 | | |
| | (15) | | | | Guidance Channel Groups specified on the "TS" card.) | | 56 57 58 59 60 | No TSG C | |
| 6162 63 64 65 | (51) | | | | | | 61 62 63 64 65 | No TSG Card(s) if NG | |
| 57 58 59 5061 62 63 64 65 66 67 68 69 7071 72 73 74 75 76 77 78 79 80 | (15) | | | | | | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | NG = 0 | PAGE |
| 71 72 73 74 75 | (15) | | | | | | 71 72 73 74 75 | | 3 OF |
| 76 77 78 7980 | (5X) | | | | (Sequence Field) | n/A | 76 77 78 79 80 | | : 4 |

Amplification of Card Type TSG

There is one card of this type for each guidance-channel group (which means that no cards are necessary if there are zero groups). The number of groups is given on Card Type TS. Each group has associated with it one or more guidance channels and services one or more launchers. When all TSG cards have been read for a ship type, a check is made to see that the total number of guidance channels and launchers over all groups corresponds to the totals given on Card Type TS. If agreement is not found, the error indicator is turned on, a message is printed, and processing continues.

| Card Columns | Description |
|--------------|---|
| 1-3 | The label TSG indicating that this is a wea- pons configuration card for a guidance-channel group IG belonging to the ship type NST being processed. |
| 6-10 | Tracking radar type for guidance-channel group IG and ship type NST. This value refers to a data set defined by Card Types TR, TRI, and TRF or, for the radar surveillance/radar tracking version, by Card Type TR only. |
| 11-15 | The guidance-channel constraint-group type for guidance channel group IG and ship type NST. This value refers to a data set defined by Card Types TG, TGP, TGC, and TGA. The guidance-channel constraint-group type determines the number of guidance channels for group IG (Card Type TG). |
| 16-20 | The number of launcher types NLCHT serviced by guidance-channel group IG. |
| 21-25 | The first launcher type M _{1,IG} serviced by guidance-channel group IG. This value refers to a data set defined by Card Type TL. |
| 26-30 | The number of launchers $N_{1,IG}$ of type $M_{1,IG}$ serviced by guidance-channel group IG. |

Amplification of Card Type TSG (Concluded)

| Card Columns | Description |
|--------------|---|
| 31-35 | Same as card columns 21-25 but for $^{\rm M}_{\rm 2,IG}$ if NLCHT $^{\rm 2}$ 2. |
| 36-40 | Same as card columns 26-30 but for $^{ m N}_{ m 2,IG}$ and $^{ m M}_{ m 2,IG}$ if NLCHT \geq 2. |
| 41-45 | Same as card columns 21-25 but for $^{\rm M}_{3, \rm IG}$ if NLCHT = 3. |
| 46-50 | Same as card columns 26-30 but for $^{\rm N}_{\rm 3,IG}$ and $^{\rm M}_{\rm 3,IG}$ if NLCHT = 3. |

Amplification of Card Type TSC

One TSC card is required for each component associated with ship type NST. Usually one such card is defined for each of the NR radar systems, NC guidance-channel systems, and NL launcher systems as specified on Card Type TS as well as for any other components desired to model the ship type. In the radar surveillance/radar tracking version, one TSC card must be defined for each of the surveillance radar systems, since the z coordinate of the component's position as specified in columns 26-30 is used as the radar antenna height. The sum of components taken over all ship types in a given replication may not exceed ICOMAX; the number associated with a particular ship type may range from zero to ICOMAX. Within each ship type, all type TSC cards must follow the last type TSG card and precede the type TSH card.

| Card Columns | <u>Description</u> |
|--------------|--|
| 1-3 | The label TSC indicating that this is a component card for ship type NST. |
| 6-10 | Component ID number, assigned by the user, which must be unique within ship type NST. |
| 11-15 | Component type number to be associated with this component, referring to the data set defined by cards of type TP. |
| 16-20 | x coordinate of the component's position relative to the local coordinate system of the ship type (feet). |
| 21-25 | y coordinate of the component's position relative to the local coordinate system of the ship type (feet). |
| 26-30 | <pre>z coordinate of the component's position rela- tive to the local coordinate system of the ship type (feet).</pre> |
| 31-35 | Binary flag indicating whether the component is exterior (1) or interior (0) to the ship's hull. |

Amplification of Card Type TSC (Continued)

| Card Columns | <u>Description</u> |
|--------------|---|
| 36-40 | Scenario cost index indicating the component's value to the task force overall. |
| 41-45 | System code indicating that this component is a radar (1), guidance channel (2), launcher (3), or other type of component (0 or blank). |
| 46-50 | System type number giving the radar type number, guidance-channel type number, or launcher type number, if system code above is 1, 2, or 3 respectively; the field is 0 or blank otherwise. |

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| | FORMAT | LABEL | OF VALUES | ONITS | DESCRIPTION | DISPOSITION | | | |
|--|---------|-------|--------------|---------------|-----------------------------------|-------------|---|----------------|---------------|
| 1 2 3 4 5 | EN : | | | | Labe! | N/A | - 2 | NUMBER | CARD |
| 9 | (12) | | | | (Unused integer) | N/A | 5 | 1 1 | |
| 8 7 8 9 10 11 12 13 14 15 | (F10.3) | | | meters/sec | Wind Speed | WINDSP | 6 1 8 9 1011 12 13 14 15 | 1 1 | EN |
| 16 17 18 19 20 21 22 23 24 25 | (F10.3) | | | meters | Altitude | ALTUDE | 16 17 18 19 20 21 27 23 24 25 | ENVGEN | Environmental |
| 26 27 28 29 30 JI 32 JJ JK 35 | (F10.3) | | 0 to 1 | | Nominal reflection coefficient | REFCOF | 26 21 28 79 30 31 32 33 34 35 | NOUTINE ENVIEN | al data card |
| 16 37 38 39 40 41 42 43 44 46 | (F10.3) | | 0 or 1 | | Multipath indicator | FMULT | 16 37 38 39 40 41 42 43 44 45 | REMARKS | |
| 384 55 88 | (F10.3) | | | millimeters/h | Rainfall rate | RAIN | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 5 | | |
| 57 58 59 50 61 62 63 64 60 <mark>66 67 68 69 70</mark> 71 72 73 74 75 76 77 78 79 80 | | | | | | · | 17 58 59 60 61 62 63 64 65 86 67 68 69 74 71 72 73 74 75 78 77 78 79 80 | | PAGE 1 |
| 75 76 77 78 79 80 | (5X) | | | | | | 175 76 77 78 79 80 | | or 2 |

Amplification of Card Type EN

Card Type EN furnishes the scenario environmental data for a game replication. This card, if present in the input deck (see Card Type EX for default option), must follow Card Type CX, the communications-generator trailer card.

| Card Columns | . <u>Description</u> |
|--------------|--|
| 1-2 | The label EN indicating that this is an en- vironmental data card. |
| 6-15 | Wind speed, expressed in meters per second. |
| 16-25 | Altitude at which the wind speed is taken, expressed in meters. |
| 26-35 | Nominal reflection coefficient. |
| 36-45 | Multipath indicator (defined for the radar surveillance/radar tracking version only): |
| | 0 = no multipath propagation |
| | nonzero = multipath propagation. |
| 46-55 | Rainfall rate, expressed in millimeters/hour (defined for the radar surveillance/radar tracking version only). |

| ٢ | õ | 22 | <u> </u> | R | ç | | |] | | |
|--|--------|-------|---------------|-----|-------|------------------|-------------|--|--------------------|-----------------|
| | FORMAT | LABEL | VALUES | NGE | UNITS | DESCRIPTION | DISPOSITION | | | |
| 1 2 3 | EX | | | | | Label | N/A | 1 2 3 | FORMAT | CARD NAME |
| 4 5 6 | (12) | | | | | (Unused Integer) | N/A | 4 5 | ER | EX |
| | (15) | : | | | | | | 6 7 8 9 10 | 2 | |
| 11 12 13 14 1 | (15) | | | | | | | 11 12 13 14 15 | READING ROUTINE | PURPOSE |
| 16 17 18 19 2 | (15) | | | | | | | 5 16 17 18 19 20 | ENVGEN | Environmental |
| 0212223242 | (15) | | - | | | | | 021 22 23 24 25 | | mental Data |
| 7 8 9 10 11 12 13 14 15 15 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 35 37 38 39 40 41 42 43 44 45 48 49 50 81 52 53 54 55 65 57 58 59 50 61 62 63 64 65 66 67 68 69 70 77 77 77 74 78 76 77 78 79 80 | (15) | | | | | | | 5 26 27 28 29 3 | ROUTINE | ta Trailer Card |
| 031 32 33 34 38 | (15) | | | | | | | 0 31 32 33 34 35 | HOUTINE ENVGEN | Card |
| 36 37 38 39 40 | (25) | | | | | | | 36 37 38 39 40 | | |
| 041 42 43 44 48 | (15) | | | | | | | 41 42 43 44 45 | REMARKS | |
| 46 47 48 49 50 | (15) | | | | | | | 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 | | |
| 51 52 53 54 55 | (15) | | | | | · | | | | |
| 56 57 58 59 50 | (15) | | | | | | | 56 57 58 59 60 | | |
| 6162 63 64 65 | (15) | | | | | | | 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | | |
| 86 67 68 69 70 | (15) | | | | | | | 66 67 68 69 70 | | PAGE |
| 71 72 73 74 75 | (15) | | | | | | | 71 72 73 74 75 | | 2 OF |
| 76 77 78 7980 | (5X) | | | | | | | 76 77 78 79 80 | | 2 |

Amplification of Card Type EX

Card Type EX is the trailer card for the environmental generator and must always appear in the input deck. If no Card Type EN is present, then the default option of zero for wind speed, altitude, reflection coefficient, multipath propagation, and rain is used. Upon reading this card, execution control is returned to the GENER8 program.

Card Columns

Description

1-2

The label EX indicating that the environmental data have been read.

| | FORMAT | LOCAL | RANGE OF VALUES | STINO | DESCRIPTION | DISPOSITION |] | | |
|---|---------|-------|-----------------------|-----------------|--|------------------------------|---|-------------------------------------|----------------|
| 1 2 3 | R W | | | | Label | N/A | 1 2 3 | FORMAT NUMBER | CARD |
| 4 5 | (I2) | | | | (Unused Integer) | N/A | 4 5 | | RW |
| 6 7 8 9 10 | (15) | MPRF | 1 to 31 | integer | Weapon Profile number | N/A | 6 7 8 9 10 | 5 | W |
| 11 12 13 14 15 | (15) | LEGS | 1,3, or 4 only | integer | Number of legs in the flight path for this Weapon Profile | JWPRF _a (MPRF) | 11 12 13 14 15 | READING | PURPOSE |
| 12 13 14 15 16 17 18 19 20 21 | (15) | | > 0 | feet/ second | $\mathbf{S}_1^{}$, weapon speed along 1st Flight Path Leg | PATHS (JPATH+1) | 16 17 18 19 20 | RAIDGN | Weapon Profile |
| 21 22 23 24 25 | (15) | | > 0 | feet/ second | S_2 , weapon speed along 2nd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+4) | 21 22 23 24 25 | | ofile Des |
| 26 | (15) | | > 0 | feet/ second | S ₃ , weapon speed along 3rd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+6) | 26 27 2 | USING ROUTINE | Description |
| 27 28 29 30 31 32 33 34 35 | (15) | | > 0 | feet/ second | S ₄ , weapon speed along 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+8) | 31 32 33 34 35 | WPNGEN | |
| 36 37 38 39 40 | (15) | | € 89 | degrees | θ_1 , absolute value of climb (or dive) angle at beginning of 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+2) | 36 37 38 39 40 | | |
| 41 42 43 44 45 | (15) | | ≤ 89 | degrees | θ_2 , absolute value of climb (or dive) angle at the end of the 2nd Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+5) | 41 42 43 44 45 | REMARKS | |
| 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 | (F10.3) | | 0 ≥ | kft | A_1 , cruise altitude reached at the end of the 1st Flight Path Leg (N/A if LEGS = 1) | PATHS (JPATH+3) | 46 47 48 49 50 51 52 53 54 55 | · | |
| | (F10.3) | | ≥ 0 | kft | A_2 , cruise altitude reached at the end of the 3rd Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+7) | 56 57 58 59 60 61 62 63 64 65 | JPATH+1 → JWPRF _b (MPRF) | |
| 57 58 59 50 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | (F10.3) | | ≥ 0 | kft | D, length of the 4th Flight Path Leg (N/A if LEGS = 1 or 3) | PATHS (JPATH+9) | 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 | MPRF) | PAGE 1 OF |
| 76 77 78 79 80 | (5 X) | | | | (Sequence Field) | n/a | 76 77 78 79 80 | | <u>"</u> |

| A. | Packed list name | IRADPC* | BPU name | IBITS2 . Cor | mmon block | name | RADAR |
|----|------------------|---------|-----------|--------------|--------------|------|-------|
| В. | One packed group | per F | Radar Set | of which | ch there may | y be | 63 |

C. Packing Format:

| First Bit. No | Field Width | Purpose | Remarks |
|---------------|----------------|-------------------------------|------------------------|
| a 1 | 1 | Disabled (1) or not (0) | |
| b 2 | 1 | Activated (1) or not (0) | Note #1 |
| c 3 | 4 | Radar simulation model option | Note #2 |
| d 7 | 6 | Radar type number | |
| 6 13 | 6 | Associated ship number | |
| f 19 | 6 | Sigma of range error | range resolution cells |
| g 25 | 6 | Sigma of azimuth error | mils |
| | | | |

| D. | Bits per unit | 30 , | . Total packed list length | 1,890 | bits |
|----|---------------|------|----------------------------|-------|------|
| ₽. | pres ber dure | | i torat backer trac tenden | | |

E. List dimension on machine with word length of:

| 60 | bits | . 32 | words; 36 | bits | 53 | words; | bits | word |
|----|------|------|-----------|------|----|--------|------|------|
| | _ | | | | | | | |

F. Notes:

 $^{^{\#1}}$ Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.

 $^{^{\#2}{\}rm Fields}$ a, b, and c would normally be picked up together as a single 6 bit field, with a value greater than 31 implying a disabled radar set.

^{*}IRADPC packed list format for TDHS version.

| | | | radar set . of which the | re may be 03 |
|-------|------------------|----------------|---|--------------|
| cking | Format: | : | | Y |
| ield | First Bit. No | Field Width | Purpose | Remarks |
| a | J | 1 | Disabled (1) or not (0) | |
| b | 2 | ן | Activated (1) or not (0) | Note 1 |
| С | 3 | 4 | Radar simulation model option | Note 2 |
| d | 7 | 6 | Number of radar scan modes (> 0 for a surveillance radar and 0 for a track-ing radar) | |
| e | 13 | 6 | Associated ship number | V |
| f | 19 | 2x6 | No. of primary detections achieved | |
| g | 31 | 1 | Radar mode 1 activated (1) or not (0) | |
| h | 32 | 7 | Radar mode 2 activated (1) or not (0) | |
| : | : | : 1 | Radar mode n activated (1) or not (0) | |
| u , | 45 | 1 | Radar mode 15 activated (1) or not (0) | |
| | | | | |
| | c unit | 45 | . Total packed list length 2835 hine with word length of: | bits. |

- 1. Field b is set to "1" by the ENTER event when the initial scan for this radar is scheduled.
- Fields a, b, and c would normally be picked up together as a single six-bit field, with a value greater than 31 implying a disabled radar set.

| Α. | Packed list n | name IRDRPC | BPU name | IBITS3. | Common | block name | RADAR |
|----|---------------|------------------------|----------|---------|-----------|-------------|-------|
| в. | One packed gr | roup per <u>Rada</u> ı | Туре | of | which the | re may be _ | 31 |

| c. | Packing | Farmat. |
|---------|---------|---------|
| \cdot | Packing | roimat. |

| rackii | ng Format | | • | |
|--------|------------------|----------------|--|---------|
| Field | First Bit No. | Field Width | Purpose | Remarks |
| а | . 1 | 1 | Old (0) or new (1) type data | |
| b | 2 | 1 | Good (0) or bad (1) type data | Note #1 |
| С | 3 | 3 | Radar frequency band index | · |
| d | 6 | 5 | Target acquisition delay for tracking radars | seconds |
| е | 11 | 5 | Kill evaluation delay for tracking radars | . 11 |
| f | 16 | 5 | Surveillance radar scan rate | " |
| g | 21 | 3x5 | Maximum unambiguous range | kft |
| · | | | | |
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| D. | Bits per unit | . Total packed list length | 1,085 | bits. |
|----|----------------|---------------------------------|-------|-------|
| E. | List dimension | on machine with word length of: | | |
| | 60 bits | 19 words; 36 bits 31 words; | bits | words |
| F. | Notes: | • | | |

#1. These three fields together constitute a single 5 bit field during the play of the game (at which time fields a and b should both be zero).

| One pa | cked grou | ip per | radar type of which then | re may be 31 |
|--------|------------------|----------------|---|--------------|
| Packin | g Format: | | | |
| Field | First Bit. No | Field Width | Purpose | Remarks |
| a | 1 | 1 | Old (O) or new (1) type data | |
| b | 2 | 1 | Good (0) or bad (1) type data | Note 1 |
| С | 3 | 3 | Type of radar (1) for surveillance and (2) for tracking/fire control | |
| d | 6 | 5 | Target acquisition delay for tracking radars | Seconds |
| e | 11 | 5 | Kill evaluation delay for tracking radars | Seconds |
| f | 16 | 5 | Number of radar scan modes (> 0 for a surveillance radar and 0 for a track-ing radar) | |
| g | 21 | 3x5 | Unused | |
| | | | | |
| | , | i | | |

 These three fields together constitute a single five-bit field during the play of the game (at which time fields a and b should both be zero).

words; 36 bits 31 words; bits

19

60 bits

F. Notes:

| A. | Packed list name | NCCCDT . | BPU name | NB7 | Common block name | COMPON |
|----|------------------|------------|----------|-----|--------------------|--------|
| B. | One packed group | per Compon | ent | of | which there may be | 620 |

C. Packing Format:

| Field | First Bit. No | Field Width | Purpose | Remarks |
|-------|------------------|----------------|---|------------------|
| a | 1 | 25 | Cumulative costs | In units of Q7Q1 |
| Ъ | 26 | 25 | Current cost (D) | In units of Q7Q2 |
| ċ | 51 | 25 | Cumulative cost since last repair event (d) | |
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| D. | Bits | per unit | <u>75</u> | Total | packed | list | length | 46,500 | _bits. |
|----|------|-----------|--------------|-----------|--------|------|--------|--------|--------|
| E. | List | dimension | on machine w | with word | length | of: | | | |

60 bits 775 words; 36 bits 1292 words; bits words

| | First | Field | | |
|--------|---------|-------|--|-------------------------|
| ield | Bit. No | Width | Purpose | Remarks |
| a | 1 | 1 | Old (O) or new (l) group data | |
| b | 2 | 1 | Good (0) or bad (1) group data | |
| С | 3 | 3 | Option number | 1, 2, 3, or 4 Note 1 |
| d | 6 | 3 | Number of rows in cross-section data array | |
| е | 9 | 3 | Number of columns | |
| f | 12 | 3 | Marcum-Swerling cross-section model number | 0, 1, 2, 3, or 4 |
| y | | | | |
| | | | · | |
| | | | · | |
| its pe | r unit | 14 | . Total packed list length210 | bits. |

| Common block na | ıme |
|-----------------|-----|
|-----------------|-----|

DROPQ

Sizes: Full

_, Reduced __ 55

5

| E11 | | | | | |
|-----------|-----|---|--|--|--|
| Full Red. | | Description | | | |
| | 1 | Points to the location in the array KTSQ (below) of the next track to be removed from the queue. | | | |
| | . 1 | The number of tracks currently stored in the array KTSQ. | | | |
| | 1 | The dimension of the array KTSQ. | | | |
| | 20 | An array, called the drop-track queue, which contains tracks to be dropped by the track supervisor. | | | |
| | 20 | The time that a track was entered into the array KTSQ. | | | |
| | 4 | An array containing the minimum and maximum drop- track queue lengths along with two parameters used to compute the average queue length during the game. | | | |
| | 2 | The time at which the minimum and maximum queue length, respectively, was attained. | | | |
| | 6 | A 2 x 3 array where column 1 contains the minimum waiting time along with the time of occurrence, column 2 the maximum and its occurrence time, and row 1, column 5 the total waiting time. | | | |
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| | | 1 1 20 20 4 | | | |

Common block name

ENVRON

Sizes: Full 3 or 5, Reduced 3 or 5.

| Parameter | Dimensions | | en en en en en en en en en en en en en e | | | | |
|---------------------------------------|------------|------|---|--|--|--|--|
| Name | Ful1 | Red. | Description | | | | |
| WINDSP | 1 | 1 | Wind speed (scenario). | | | | |
| ALTUDE | 1 | 1 | Altitude at which the wind speed was taken. | | | | |
| REFCOF | 1 | 1 | Nominal reflection coefficient. | | | | |
| FMULT | 1 | 1 | Multipath indicator.* | | | | |
| RAIN | 1 | 1 | Rainfall rate.* | | | | |
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^{*} Radar surveillance/radar tracking version only.

| | | | | | | | 7 | | T |
|--------|-------|-----------|-------|----|--------|------|----------|------------|-----|
| Common | block | name | RADAR | | Sizes: | Full | 378 | _, Reduced | 354 |
| Common | DIOCK | II Cuit C | | —՝ | 02202. | , | <u> </u> | _, | |

| Parameter | Dimen | sions | Department | | | |
|-----------|-----------------|-------|---|--|--|--|
| Name | Full | Red. | Description | | | |
| IRADPC | 32 [*] | 8 | Packed list of integer parameters for up to IRMAX radar sets. | | | |
| IBITS2 | 1 | 1 | The number of bits required to store the information in IRADPC for one radar set. | | | |
| IRDRPC | 19* | 19* | Packed list of integer parameters for up to NRTMAX radar types. | | | |
| IBITS3 | 1 | 1 | The number of bits required to store the information in IRDRPC for one radar type. | | | |
| IRDROP | 45* | 45* | Packed list containing radar simulation model integer parameters for up to NRTMAX radar types | | | |
| IBITS4 | 1 | 1 | The number of bits required to store the option information in IRDROP for one radar type. | | | |
| RC | 8,31 | 8,31 | Array of as many as 8 floating point parameters for up to NRTMAX radar types. | | | |
| XLMDA | 31 | 31 | Normalized threshold used in probability of detection computation. | | | |
| | | | | | | |

Notes:

 $^{^{*}}$ These figures are based upon a machine word length of 60 bits.

For the radar surveillance/radar tracking version only:

Common block name

RADAR

| Parameter | Dimer | sions | | | | |
|-----------|---------------|----------------|---|--|--|--|
| Name | Full | Red. | Description | | | |
| IRADPC | 32* | 8* | Packed list of integer parameters for up to IRMAX radar sets. | | | |
| IBITS2 | 1 | 1 | The number of bits required to store the information in IRADPC for one radar set. | | | |
| IRDRPC | 19* | 19* | Packed list of integer parameters for up to NRTMAX radar types. | | | |
| IBITS3 | 1 | 1 | The number of bits required to store the information in IRDRPC for one radar type. | | | |
| RBPAR | 10,31) | (10,31) | Array of ten basic radar parameters for up to NRTMAX radar types. | | | |
| RMPAR | 16,15, 31) | (16,15, 31) | Array of 16 radar-mode parameters for up to 15 modes on each of at most NRTMAX radar types. | | | |
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^{*} These figures are based on a machine word length of 60 bits.

Common block name RADSEC . Sizes: Full 441 , Reduced 105

| Parameter | Dimen | sions | |
|-----------|-------|-------|--|
| Name | Full | Red. | Description |
| RSECT | 63 | 15 | Right hand boundary of coverage sector for each of up to IRMAX radar sets. |
| WIDE | 63 | 15 | Width of the radar coverage sectors. |
| COSRT | 63 | 15 | Cosine of the right hand coverage sector boundary angle. |
| SINRT | 63 | 15 | Sine of the right hand coverage sector boundary angle. |
| COSLF | 63 | 15 | Cosine of the left-hand coverage sector boundary angle. |
| SINLF | 63 | 15 | Sine of the left-hand coverage sector boundary angle. |
| RZROOT | 63 | 15 | Square root of the radar set antenna height. |
| | | | |

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Common block name RSET . Sizes: Full _____, Reduced ______10

| Parameter | Dimensions | | | | | |
|----------------|------------|------|---|--|--|--|
| Name Full Red. | | Red. | Description | | | |
| COSTHT | | 1 | The cosine of the angle* of rotation. Applicable only if the reachable set is an ellipse. | | | |
| SINTHT | | 1 | The sine of the angle of rotation. Applicable only if the reachable set is an ellipse. | | | |
| BSQ | | 1 | Computed as $1.0 \cdot E^2$ where E is the eccentricity of the ellipse. Applicable only if the reachable set is an ellipse. | | | |
| MRSOPT | | 1 | Indicates the form of the reachable set where 1 means a circle and 2 an ellipse. | | | |
| RADSQ | | 1 | The square of the radius limiting the size of the reachable set. | | | |
| SFACTR | | 5 | An array of 5 scale factors which are used to increase or decrease the size of the reachable set. The factors are a function of the number of reports in the track history. | | | |
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Notes:

*e.g., the angle between the X-axis and the current flight path leg of of the target under consideration.

For the radar surveillance/radar tracking version only:

Common block name SCAN* . Sizes: Full ____7 , Reduced ___7 ___.

| Parameter | rameter Dimensions | | | | |
|-----------|--------------------|------|---|--|--|
| Name | Full | Red. | Description | | |
| IRB | 1 | 1 | Radar frequency band index. | | |
| NG | 1 | 1 | Target cross-section group number. | | |
| IOPT | 1 | 1 | Target cross-section option number. | | |
| NROW | 1 | 1 | Number of rows in the cross-section data array. | | |
| NCOL | 1 | 1 | Number of columns in the cross-section data array. | | |
| MODEL | 1 | , 1 | Marcum-Swerling target model number. | | |
| ASPCT | | 1 | Aspect angle of the target with respect to the radar. | | |
| | | | | | |

^{*} This common block serves as a linkage between the SCAN event and the target cross-section calculation in the SURSEM submodel.

Common block name SHIP . Sizes: Full 566*, Reduced 432*

| Parameter | Dimensions | | | | |
|-----------|------------|------|---|--|--|
| Name | Full | Red. | Description | | |
| ISHPF0 | 49* | 11* | Packed list of integer parameters for up to ISMAX ships. | | |
| IBITS5 | 1 | 1 | The number of bits required to store information in ISHPFO for one ship. | | |
| KRSHPT | 19* | 19* | Packed list containing radar types for up to NSTMAX ship types. | | |
| KBITS4 | 1 | 1 | The number of bits required to store information in KRSHPT for a maximum of seven radar sets for a single ship type. | | |
| MNSHPT | 163* | 163* | Packed list of guidance-channel-group integer parameters for up to NSTMAX ship types. | | |
| MBITS1 | 1 | 1 | The number of bits required to store information in MNSHPT for a maximum of seven guidance-channel groups for a single ship type. | | |
| NPSHPT | 20* | 20* | Packed list of integer parameters for up to NSTMAX ship types. | | |
| NBITS4 | 1 | 1 | The number of bits required to store information in NPSHPT for one ship type. | | |
| NVSHPT | 155* | 155* | Packed list of component position and vulner- ability data for up to NSTMAX ship types. | | |
| NBITS6 | 1 | 1 | The number of bits required to store information in NVSHPT for up to ten component groups for a single ship type. | | |
| SHIPOS | 3,31 | 3,7 | Array of position coordinates (X,Y,Z) for up to ISMAX ships. | | |
| INRNG | 31 | 7 | Array of in-range target counters for up to ISMAX ships. | | |
| TKESTM | 31 | 31 | Array of time windows for track establishment by up to NSTMAX ship types. (For the radar surveillance/tracking version only.) | | |

^{*} These figures are based on a machine word length of 60 bits.

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Common block name TARGET . Sizes: Full 2113*, Reduced 497

| | | | 2137‡ 421‡ | | | | |
|-----------|-------|-------|--|--|--|--|--|
| Parameter | Dimen | sions | Description | | | | |
| Name | Full | Red. | Description | | | | |
| DISP | 3,255 | 3,63 | Array of target displacements ($\Delta X, \Delta Y, \Delta Z$) from the associated master flight paths. | | | | |
| ENDGTM | 1 | 1 | The latest target node time from which parasite launches are referenced or, if there are no parasites, the latest node time of any target. | | | | |
| JPAR | 1 | 1 | The total number of parasite targets specified in the RAIDGN inputs. | | | | |
| JTGT | 1 | 1 | The total number of targets, including parasites, specified in the RAIDGN inputs. | | | | |
| JTRGFO | 319* | 79* | Packed list of integer parameters for up to JTMAX targets. | | | | |
| JBITS3 | 1 | 1 | The number of bits required to store information in JTRGFO for a single target. | | | | |
| JWPRF | 8 | 8 - | Packed list of integer parameters for up to JWPMAX weapon profile descriptions. | | | | |
| JBITS4 | 1 | 1 | The number of bits required to store information in JWPRF for one weapon profile. | | | | |
| NTGPAR | 14* | 14* | Packed list of integer parameters for up to NTIMAX target types. | | | | |
| NBITS5 | 1 | 1 | The number of bits required to store information in NTGPAR for one target type. | | | | |
| LPATH | 1 | 1 | Dimension of the PATHS array. | | | | |
| PATHS | 1000 | 200 | Array of master flight path and weapon profile data. | | | | |
| JTFAIL | | 23 | Packed list of failure probabilities for up to JTMAX targets. | | | | |
| JBITS7 | | 1 | The number of bits required to store the failure probabilities in JTFAIL for one target. | | | | |
| | | | | | | | |

Notes:

 $^{^{*}}$ These figures are based upon a machine word length of 60 bits.

[†]The dimension of the PATHS array is set arbitrarily; generation of numerous and lengthy MFPs and weapon profiles would necessitate increasing the dimension of this array.

[‡]These sizes include the storage unique to the TDHS version.

For the radar surveillance/radar tracking version only:

| Common block name | TARST | • | Sizes: | Full | 63 | , Reduced | 63 | |
|-------------------|-------|---|--------|------|----|-----------|----|--|
| | | | | | | | | |

| Parameter | Dimens | sions | | | | |
|-----------|--------|-------|--|--|--|--|
| Name | Full | Red. | Description | | | |
| ITARST | 63 | 63 | STATUS (active or inactive) of up to JTMAX targets at current game time SIMTIM | | | |
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Common block name <u>TECOMM</u>. Sizes: Full <u>332</u>*, Reduced <u>84</u>*

| Parameter | Dimen | sions | | | |
|-----------|-------|-------|--|--|--|
| Name | Full | Red. | Description | | |
| ICOMM | 17* | 1* | Packed list of intership-communication-link status values. | | |
| IBITS6 | 1 | 1 | The number of bits required to store the communications link status data in ICOMM for one ship (receiver). | | |
| IXMIT | 1 | 1 | An indicator that will override use of the ICOMM list if not equal to 0. If < 0, then no links ever exist; if > 0, then all links alway exist. | | |
| IMODIF | 17* | 1* | Packed list specifying which intership com- munications links are allowed to be modified by the effects of enemy jamming. | | |
| IBITS7 | 1 | 1 | The number of bits required to store the modification specifications in IMODIF for one ship (receiver). | | |
| MODIFY | 1 | 1 | An indicator that will override use of the IMODIF list if not equal to 0. If < 0, then no links are allowed to be modified; if > 0, then all links are allowed to be modified. | | |
| COMDLY | 1 | 1 | Intership-communications time delay (seconds). | | |
| FDETM | 31 | 7 | Time at which the first target detection takes place by each of ISTOP ships; used to trigger subsequent TEWA events. | | |
| TEDLY | 1 | 1 | Time delay from first target detection to earliest possible weapon assignment (seconds). | | |
| MTHRT | 255 | 63 | Target threat number list, made up and used within the TEWA routine. | | |
| VAC | 2 | 2 | Vital Area Center position coordinates (X, Y). | | |
| THRES | 4 | 4 | Range squared threshold values used to determine the range parameter of a target's threat number. | | |
| | | | | | |

Notes:

^{*} These figures are based upon a machine word length of 60 bits.

Common block name TIMCHK . Sizes: Full 60 , Reduced 60

| Parameter | Dimens | ions | Description | | |
|-----------|--------|------|--|--|--|
| Name | Full | Red. | Description | | |
| | | | The tolerance, by event type, within which the time of a scheduled event must agree with a designated time in order for the former to be canceled from the calendar by routine CANCEL. | | |
| | | | | | |

| Common | block | name | TIMES | Sizes: | Full | 515 | Reduced | 131 |
|--------|-------|------|-------|--------|------|-----|---------|-----|
| | | | | | | | • | |

| Parameter | Dimen | sions | | | | |
|-----------|-------|-------|---|--|--|--|
| Name | Full | Red. | Description | | | |
| ABRTM | 1 | 1 | The time delay between the decision to abort a launched missile and the occurrence of the abort. | | | |
| ASGNTM | 255 | 63 | The assignment time of a guidance channel's currently held assignment. | | | |
| ENDTIM | 1 | 1 | End of play time computed by the simulation program. If there are no parasites, ENDTIM is equal to ENDGTM (see common block TARGET). If there are parasites, when time ENDGTM is reached a check is made to see if there are active parasites remaining. If there are, ENDTIM is equal to the latest impact time; if there are not, ENDTIM is ENDGTM. | | | |
| GAMTMX | 1 | 1 | End of play time specified on the game parameter card. | | | |
| RELTM | 255 | 63 | The release time of a guidance channel from its currently held assignment. | | | |
| TEWADT | 1 | 1 | The time between successive TEWA events for a ship group. | | | |
| TINF | 1 | 1 | Variable representing a time of positive infinity (arbitrarily assigned a value of 10 ²⁰). | | | |
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For the radar surveillance/radar tracking version only:

Common block name TRACK . Sizes: Full 1323 , Reduced 1323

| Parameter | Dimens | sions | |
|-----------|----------|----------|--|
| Name | Full | Red. | Description |
| ITRACK | (63,7) | (63,7) | Status of tracks for up to JTMAX targets carried by up to ISMAX ships. |
| TRKTIM | (63,7,2) | (63,7,2) | Initial and most recent detection/update times for up to JTMAX target tracks carried by up to ISMAX ships. |
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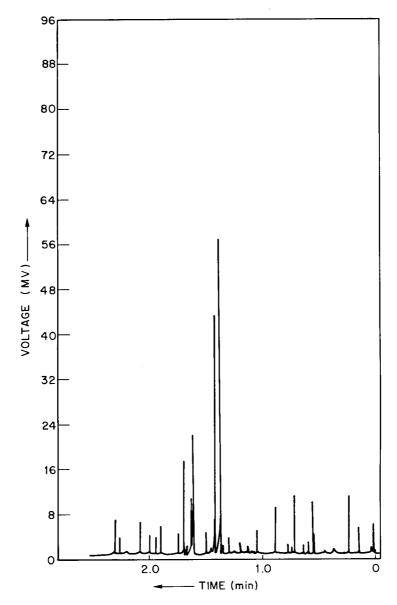


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 $\begin{array}{c} {\rm Fig.}\; 1-{\rm Typical}\; {\rm pattern}\; {\rm of}\; {\rm spontaneous}\; {\rm flashing}\; {\rm of}\; {\rm a}\; {\rm sample}\; {\rm of}\\ {\rm luminous}\; {\rm organisms}\; {\rm from}\; {\rm a}\; {\rm plankton}\; {\rm tow} \end{array}$

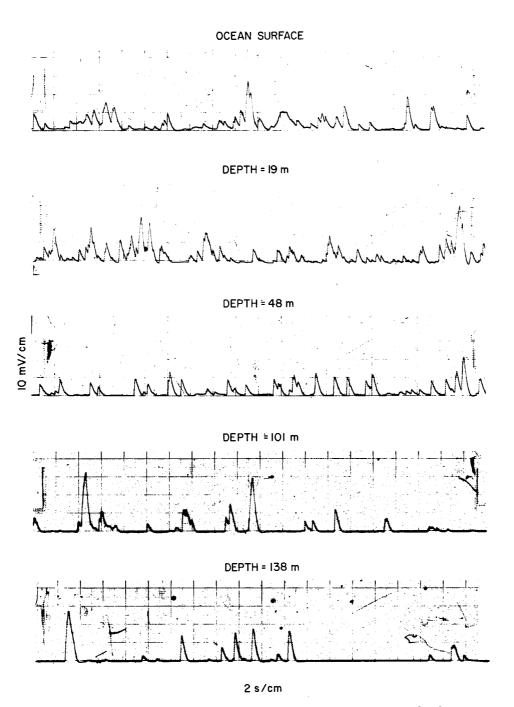


Fig. 2-A typical pattern of stimulated flashing at various ocean depths

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The Occurrence and Distribution of Surface Bioluminescence in the Oceans During 1966 Through 1977

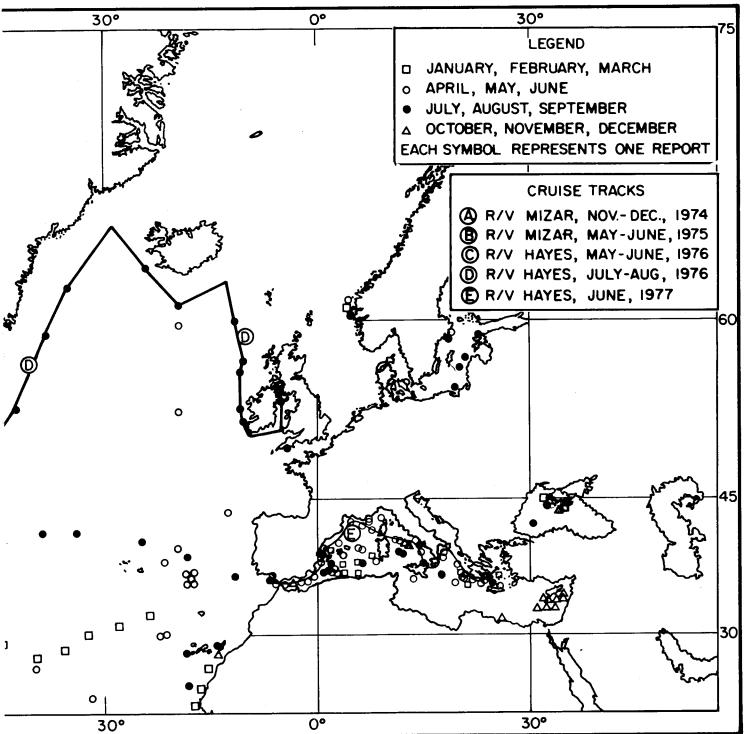
RICHARD V. LYNCH III

Marine Biology and Biochemistry Branch Ocean Sciences Division

April 26, 1978



NAVAL RESEARCH LABORATORY Washington, D.C.



istribution of bioluminescence in the northern Atlantic Ocean and adjacent seas

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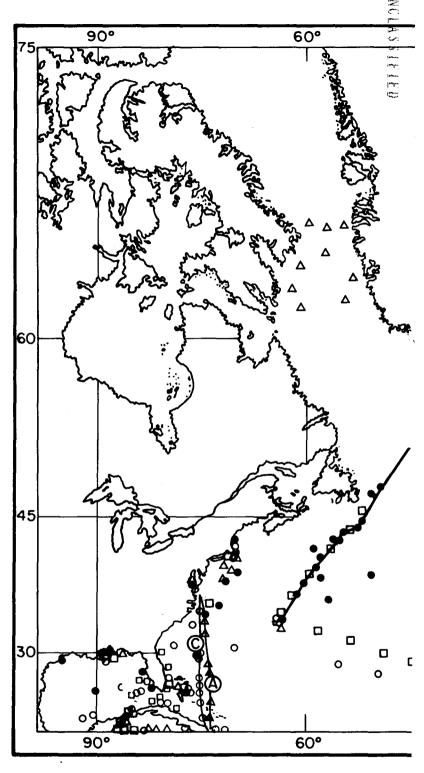
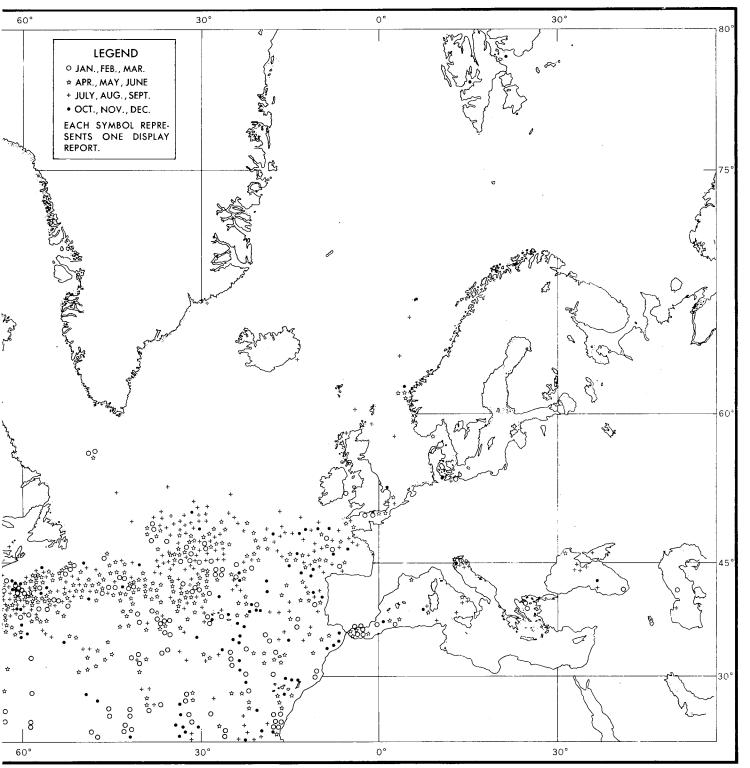


Fig. 3 — Seasonal d

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nal distribution of bioluminescent displays in the northern Atlantic Ocean and adjacent seas (Staples, 1966)

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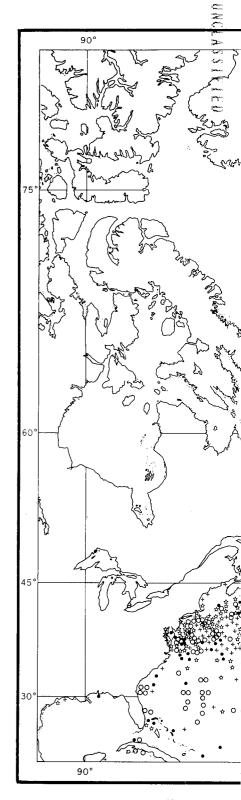


Fig. 4 — Seaso

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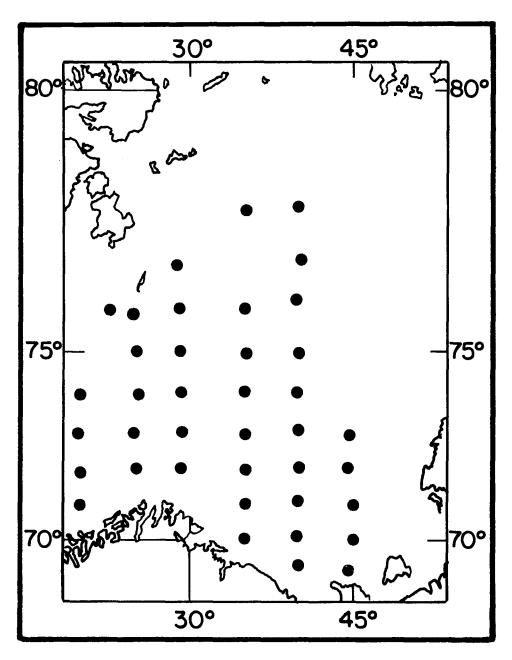


Fig. 5-Distribution of bioluminescence in the Barents Sea

concentration of this unknown substance is too low, no luciferase is synthesized and the bacterial cell maintains only a barely detectable glow. In the open sea, the concentration of luminous bacteria is too low to maintain a sufficiently high concentration of inducer molecule to permit luciferase synthesis. Consequently, in the open sea one would not expect luminescence due to luminous bacteria.

Some of the observations plotted here have not appeared in the literature. These have been personally reported to the author by reliable observers. In all such cases, the visual description provided was verified to ascertain that bioluminescence was seen and not reflected light or iridescence. In many of these cases the observation was substantiated by examination of captured luminous organisms or a portion of a recording from a bathyphotometer.

Finally, the author made bioluminescence observations on five cruises for the Naval Research Laboratory aboard the R/V MIZAR or R/V HAYES. The tracks of these cruises are shown on the maps. The tracks have been fortuitous, not planned to give a systematic survey or to study waters with known high occurrences of bioluminescence. Surface plankton tows were made twice a night, approximately one hour after sunset and two hours before sunrise along the cruise track, using a 50-cm plankton net with 35-micron mesh pore size. Tows were carried out for 15 minutes at a speed of two knots. Altogether 169 tows were made and examined for the presence of luminous organisms. In only one of these tows was no luminescence found.

Portions of the plankton catches were placed in a photometer [designed and built by Mitchell and Hastings (1971)] in a darkroom on board ship and their spontaneous flashing recorded using a Hewlett-Packard 7101 BM high-speed strip-chart recorder. Flashes were bright and numerous, although it must be pointed out that many organisms were probably excited or injured in the process of collection. A typical pattern is shown in Fig. 1. Some catches contained so much luminescence that it was almost possible to read by them.

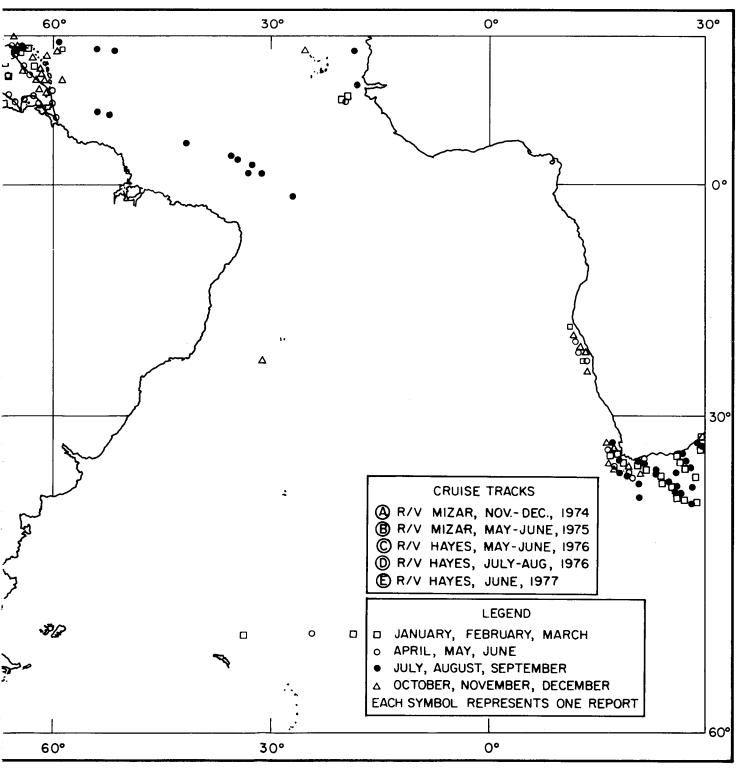
Bathyphotometer lowerings were made to as deep as 200m at several points on three of the cruises. The bathyphotometer used was a pressurized version of the one designed by Seliger, et al. (1962), with a modified pump and connected to a Sanborn Model 299 high-speed strip-chart recorder. Luminescence was recorded on every lowering, with the greatest number of flashes occurring near the surface. Typical flash patterns at various depths are shown in Fig. 2.

Several maps show a low incidence of luminescence. This dearth does not necessarily mean that luminescence in these areas was lacking, but only that no observers were present or made a report. For comparison, the maps prepared by Staples (1966) are herein reproduced.

RESULTS

Atlantic Ocean and Related Seas (Figs. 3 through 7)

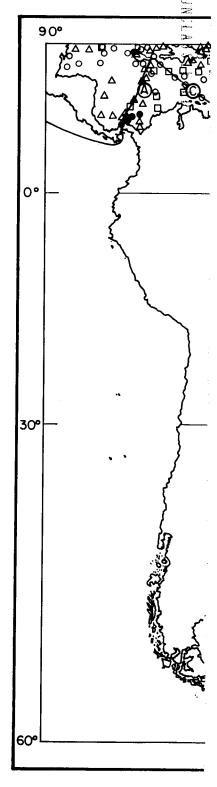
Luminous organisms of all groups were collected throughout this region in the past decade. Euphausiids and dinoflagellates were especially abundant. Luminous dinoflagellates were observed in large numbers in the Gulf of Mexico, the South Atlantic off the coast



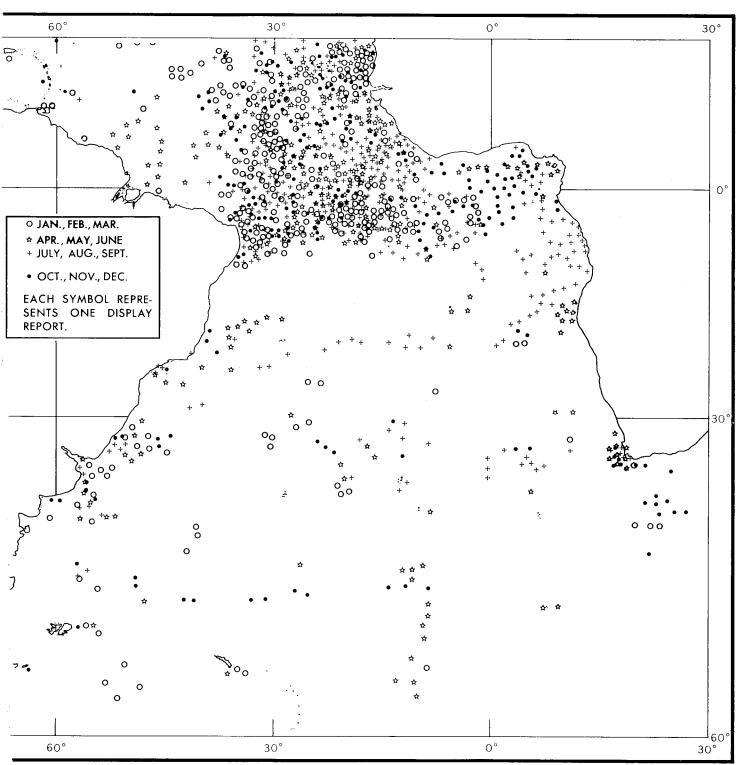
g. 6 - Seasonal distribution of bioluminescence in the southern north Atlantic and south Atlantic Oceans

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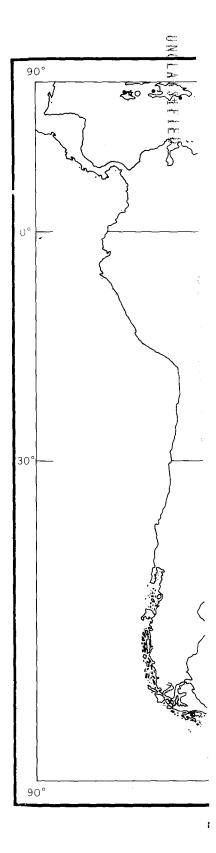


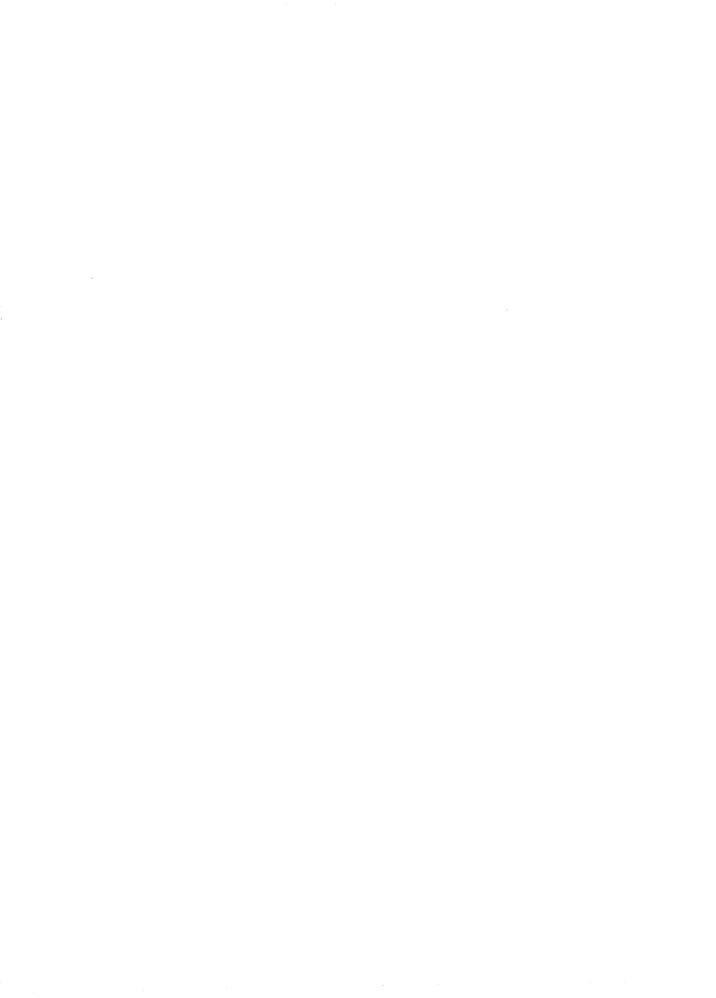


rig. 7 — Seasonal distribution of bioluminescent displays in the southern north Atlantic and south Atlantic Oceans (Staples, 1966)

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of Brazil, the Caribbean and the Barents Seas, and along the coasts of the United States, western Scotland, Norway, and the Crimean peninsula. Along the Texas, west Florida, Maine, Scotland, and Norway coasts, various species of luminous dinoflagellates were the major organisms in red tides. In Oyster Bay near Falmouth, Jamaica, and Bahia Phosphorescente and Puerto Mosquito, Puerto Rico, luminous dinoflagellates were found permanently in large concentrations. Thus, these three bays have often been called "luminous bays." In the late 1960's and early 1970's, the dinoflagellate population of Oyster Bay underwent a catastrophic decrease. The causes of this decrease are unknown but are probably related to man-made disturbances on shore. Although for several years it was thought that the bay had "died," the author observed high levels of luminescence in Oyster Bay in 1976, and was then informed that luminescence appeared to be returning slowly. Seasonally, dinoflagellates have been collected all year around and red tides generally have occurred in late spring and early autumn.

Like dinoflagellates, euphausiids have been collected from almost all of the areas shown in the maps. They were especially common in the Barents Sea and off the west coast of Scotland, and were somewhat sparse in the Mediterranean and near Iceland. In the author's collections, euphausiids occur more frequently than do dinoflagellates.

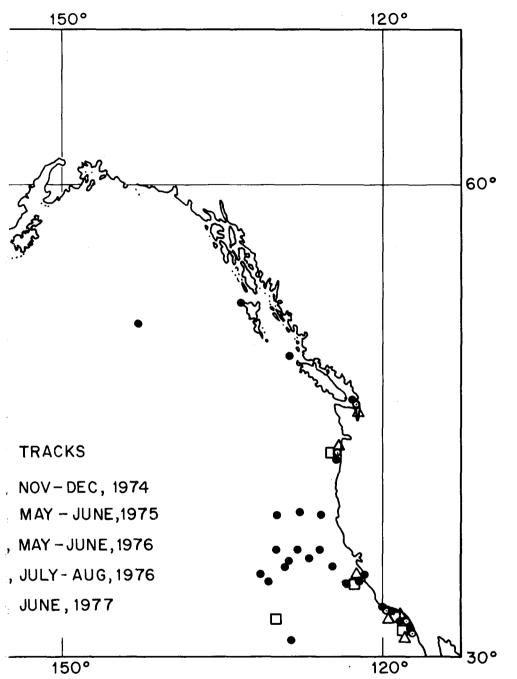
Other luminous organisms have appeared locally in large numbers. The Barents Sea has been reported rich in luminous copepods, and the author found them abundant in the western Mediterranean as well. The salp Pyrosoma is common in the eastern Mediterranean. In the heavily oil-polluted waters along the coast of Venezuela and around Trinidad, most of the plankton taken from the author's nets were dead. One of the few surviving organisms was a luminous shrimp of the genus Lucifer. Luminous coelenterates have been sporadically collected.

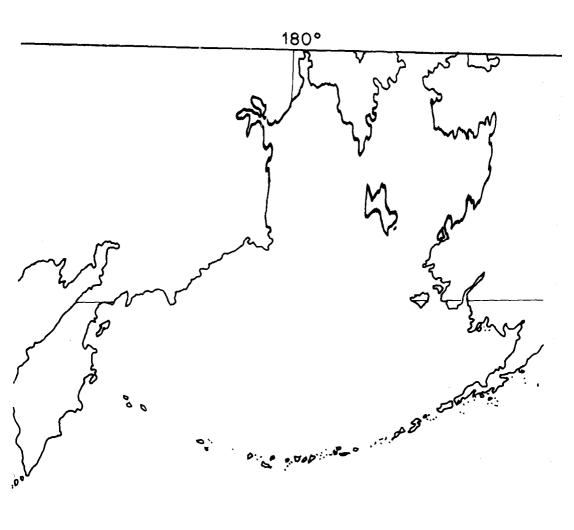
Pacific Ocean and Adjacent Seas (Figs. 8 through 13)

In the past decade too few observations of bioluminescence were made to establish any kind of distributional pattern for luminous organisms in the Pacific area. As in the Atlantic, luminous dinoflagellates were widespread, being among the most common dinoflagellates in the red tides near Los Angeles and on the Inland Sea of Japan. The author observed luminous dinoflagellate blooms near Madang, Papua New Guinea, and collected large numbers of them off the Pacific coast of Central America and northeast of Hawaii. Likewise, euphausiids were widely distributed. These were reported abundant off the coast of central California, and the author collected them all along the route on cruises from Japan to American Samoa via Papua New Guinea, and from Panama to Hawaii. They were especially abundant off the coast of Panama and near Papua New Guinea. Luminous ostracods were abundant near Tokyo Bay, Japan, Palau and Yap Islands, and Madang, Papua New Guinea. The author collected abundant luminous ctenophores south of Honshu and in the Solomon Sea. The squid Watasenia scintillans created displays on the north coast of Honshu.

Indian Ocean (Figs. 14 and 15)

The International Indian Ocean Expedition provided data on that area during the period from 1959 to 1965. The scientists involved were not primarily concerned with bioluminescence, but an analysis of known luminous species from their distributional reports





- JANUARY, FEBRUARY, MARCH

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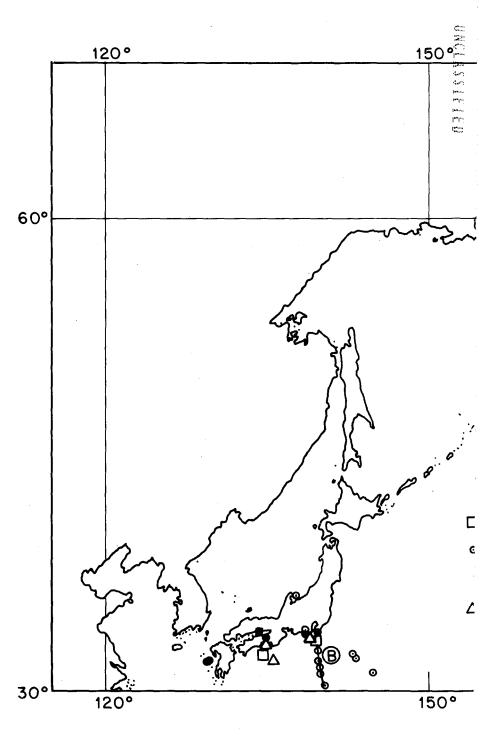
- APRIL, MAY, JUNE
- JULY, AUGUST, SEPTEMBER
- OCTOBER, NOVEMBER, DECEMBER

CRUISE

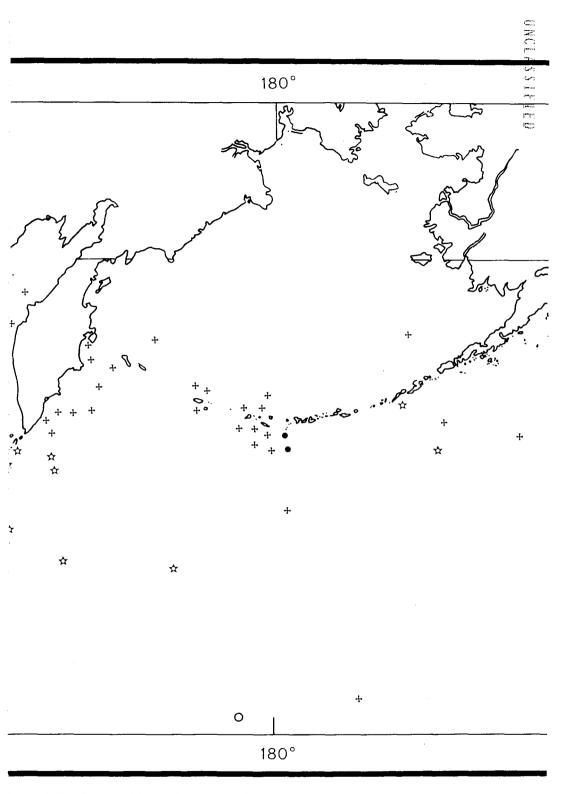
- A R/V MIZAR,
- B R/V MIZAR,
- C R/V HAYES
- D R/V HAYES
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 ${\rm Fig.~8-Seasonal~distribution~of~biolumine scence~in~the~north~Pacific~Ocean~and~adjacent~seas}$



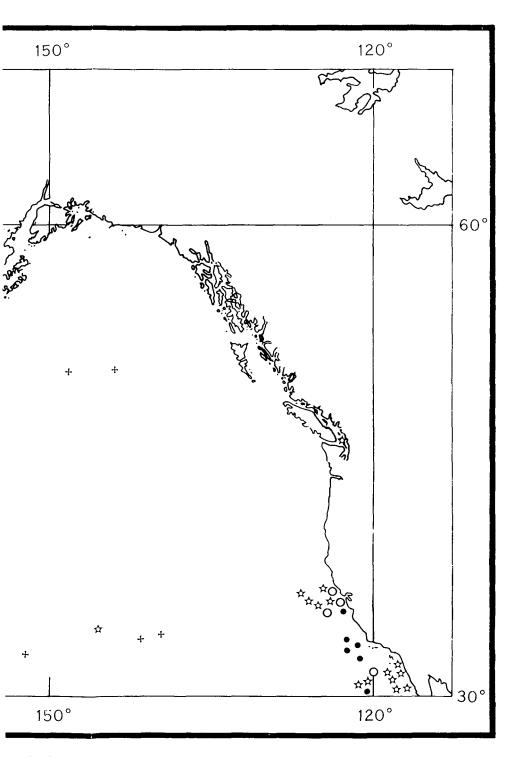




Seasonal distribution of bioluminescent displays in the north Pacific Ocean and adjacent seas (Stap

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| RESULTS | 4 |
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| Comprehension and Reliability of the Maps | 7 |
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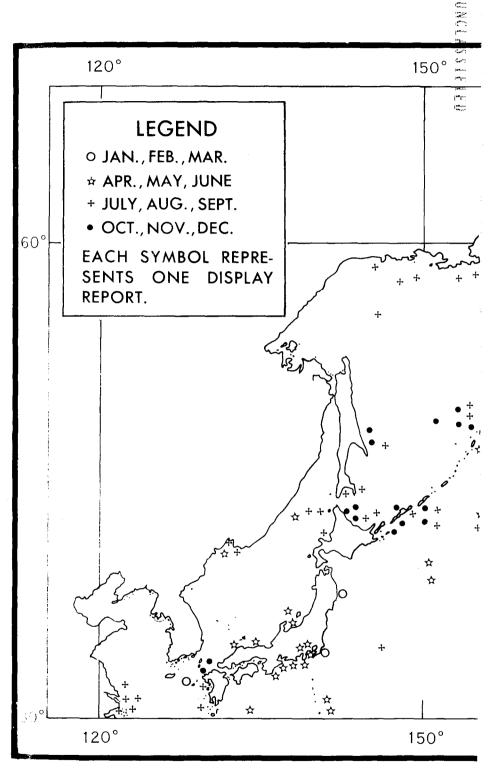


Fig. 9 -.

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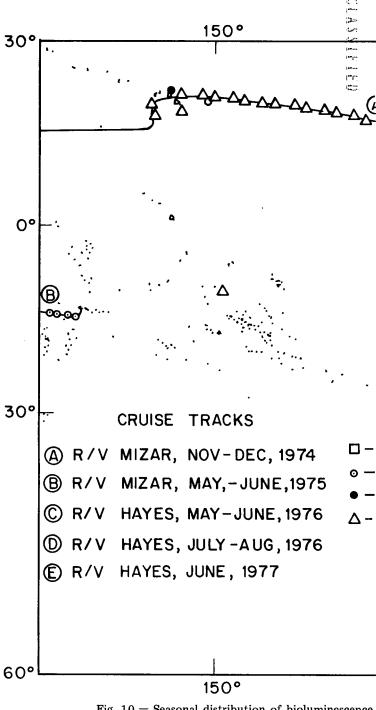


Fig. 10 — Seasonal distribution of bioluminescence

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for various planktonic groups has shown luminous organisms to occur throughout. As expected, luminous dinoflagellates and euphausiids were the most widespread and numerous. Luminous copepods were also widely distributed, while luminous salps commonly occurred around South Africa and chaetognaths in the Arabian Sea.

Plankton Tows on NRL Cruises

Out of 169 tows, bioluminescence was found in all but one. The exception was a tow made between Iceland and Greenland in August, when the night was only a few hours long. In the remaining samples, euphausiid shrimp, dinoflagellates, and copepods were the most common luminous organisms found. A partial analysis of the frequency of occurrence of common luminous organisms found is shown in Fig. 16. The random nature of the cruise tracks indicates that we might expect to find one or more of these luminous organisms at or near the surface practically everywhere in the sea.

DISCUSSION

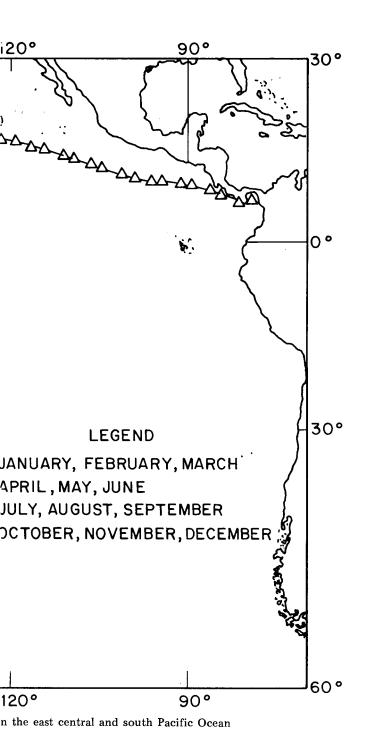
Naval Interest

Naval interest in bioluminescence centers around its use as a tool for detecting moving objects at night. If we were confined to using only luminescence visible to the human eye for this purpose, its usefulness would be very limited. However, luminescence invisible to the human eye can be detected using a LLLII. Even LLLII's have limits, as in the case where moonlight reflected from the sea surface tends to mask bioluminescence by decreasing the contrast between the luminescent area and the background. A promising approach to lessening the influence of moonlight and also to lowering the limit of detectability is to use a digital image memory processor in connection with the LLLII. The capabilities of this method are described by Mengers (1977). Even the best detectors finally encounter the limits posed by the biologies of the various luminous organisms, the physical characteristics of the emitted light, and the biochemistry of their luminescent reactions.

Biological and Physiological Characteristics

Two factors determine the potential visibility of an object in luminescent waters: the concentration of organisms present and the intensity of their emitted light. A given concentration of a bright organism might create an easily visible display, whereas an equal concentration of a dimmer organism might be seen only with difficulty, if at all. Our ability to use marine bioluminescence as a detection method thus depends on knowing the distribution of various luminescent organisms. Unfortunately, our knowledge of this area is inadequate, for there have been few scientific cruises measuring luminescence in the ocean and collecting luminous organisms. Most observations of luminescence at sea do not identify the organisms present. Seasonal and depth distributions also require study, for luminous organisms are known to migrate vertically and seasonally, and to increase in numbers during certain seasons.

Also important in determining the brightness of a display is the intensity of the stimulus. Some organisms respond to a stimulus with a flash of maximum intensity, provided



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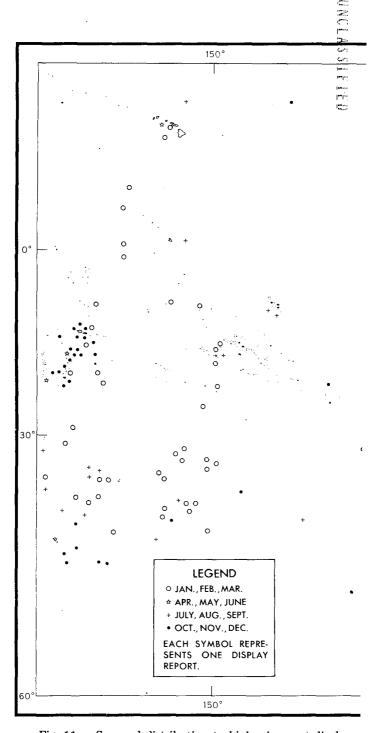
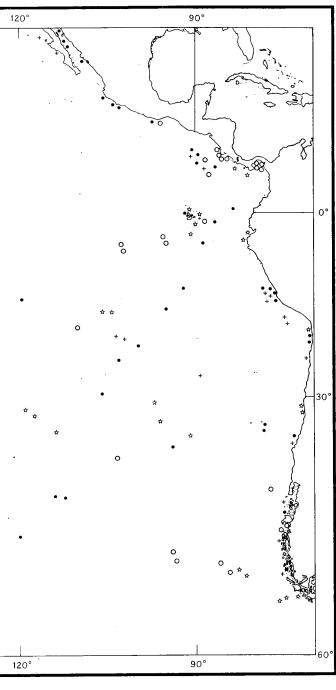


Fig. 11 - Seasonal distribution to bioluminescent displays



1 the east central and south Pacific Ocean (Staples, 1966)

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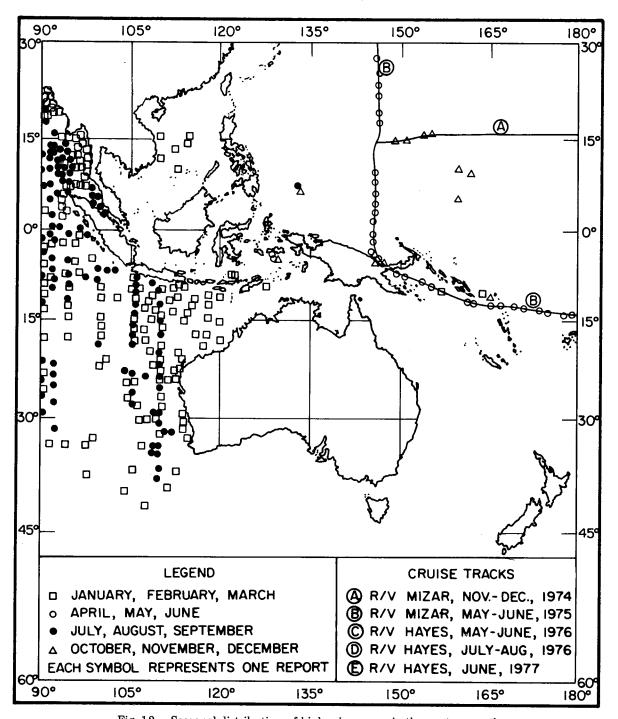


Fig. 12 — Seasonal distribution of bioluminescence in the western south Pacific and eastern Indian Oceans

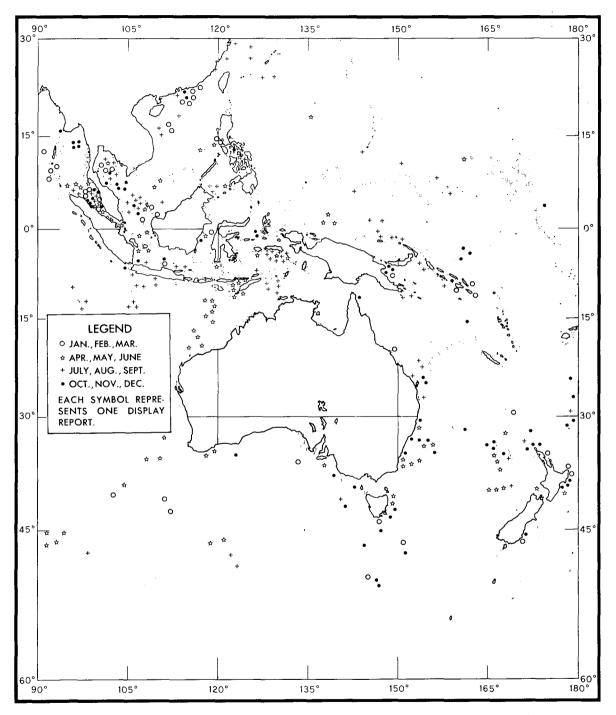
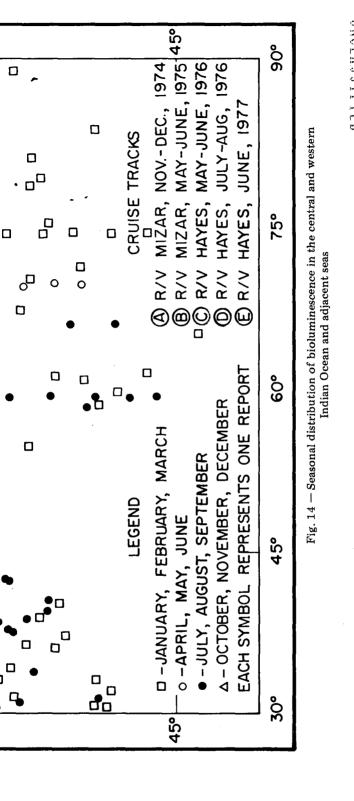
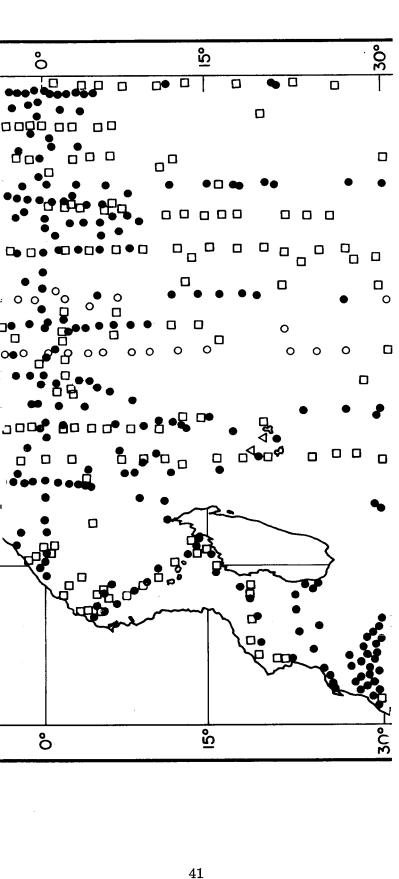


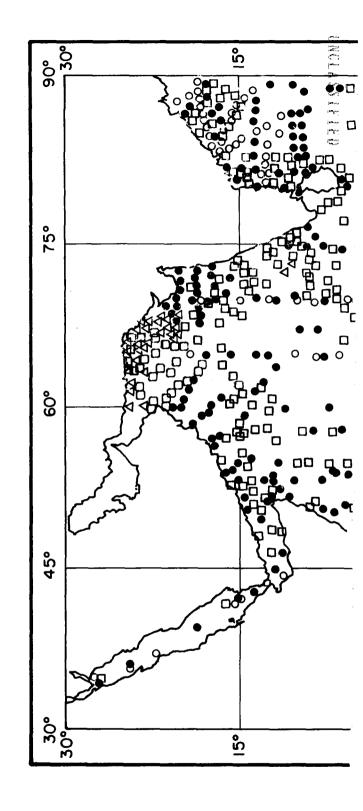
Fig. 13 — Seasonal distribution of bioluminescent displays in the western south Pacific and eastern Indian Oceans (Staples, 1966)



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that the stimulus is greater than some minimum threshold value which differs for different species. Other organisms grade the intensity of their response to the intensity of the stimulus. In either case, repeated stimuli cause repeated responses until fatigue sets in, after which no response is given to any stimulus until time has been provided for recovery. As fatigue gradually sets in, subsequent responses diminish in intensity compared to earlier responses. The rapidity of this intensity decrease, the number of responses before fatigue occurs, and the length of time needed for recovery differ for various species.

Finally, whether or not an organism responds to photic stimulation is important in determining the area of response. An organism which gives a luminous response to flashes of light creates an area of display considerably larger than the area of disturbance, because organisms near the area of disturbance, even though undisturbed themselves, respond to the light emitted by the disturbed organisms and, in turn, trigger those still further away to emit also. The visibility of a display depends on its area. Among the organisms that respond to photic stimulation are ostracods, dinoflagellates, coelenterates, ctenophores, and salps.

Physical Characteristics

It was shown above that the intensity of light emitted by an organism is important in determining the visibility of a display. Table 1 lists the intensities of emitted light for many of the known luminous marine organisms. Unfortunately, these intensities were measured by different observers and expressed in a variety of units. No attempt is here made to transform all intensities into a common set of units. Even so, one can see that the range of intensities is large. Table 1 also shows the emission wavelengths of many species; as can be seen, most luminous marine organisms emit light in the blue-green region. This means that an image intensifier maximizes light enhancement and minimizes noise if it employs a phototube with a peak response in this region. Gating could also be used to eliminate wavelengths outside the range of interest. However, since the identity of the luminous organisms present in a given area is not always known, a narrow gate could create a sampling bias.

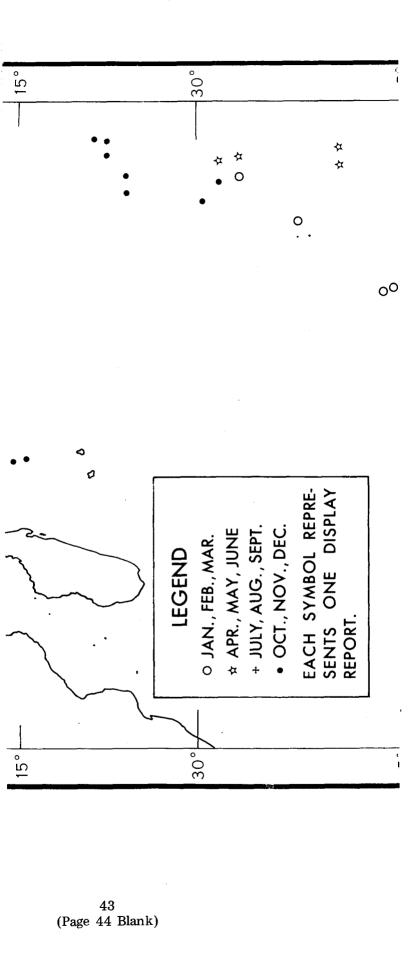
Comprehension and Reliability of the Maps

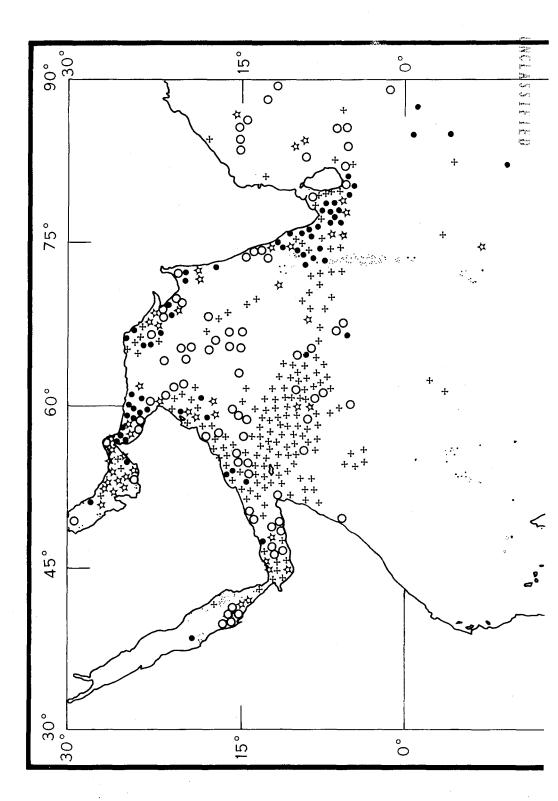
Previous studies have looked primarily at visible displays of bioluminescence in the ocean. This report is concerned not only with visible displays, but also with the general distribution of luminous organisms. The development of LLLII's, which extend our ability to detect luminous displays invisible to the unaided human eye, makes this approach valid. Thus, while this report is more comprehensive than previous ones, it covers a much smaller time span—only from 1966 to the present—while earlier reports covered all observations up to 1966.

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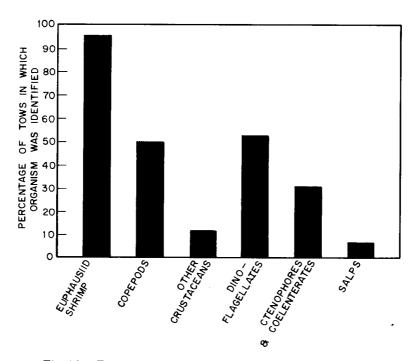
This report shares one bias with earlier reports. That is, most of the observations shown depended on the casual presence of an observer. Consequently, infrequently travelled areas show few or no observations, while heavily travelled regions show many. Therefore the number of observations in a given area cannot be taken as an indication of the relative frequency of occurrence at that location, nor can the maps be used to extrapolate or predict occurrences.

Fig. 15 — Seasonal distribution of bioluminescent displays in the central and western Indian Ocean and adjacent seas (Staples, 1966)





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 ${\it Fig.\,16-Frequency\ of\ occurrence\ of\ luminescent\ organisms\ in} \\ {\it plankton\ tows\ on\ NRL\ cruises}$

OCCURRENCE AND DISTRIBUTION OF SURFACE BIOLUMINESCENCE IN THE OCEANS DURING 1966 THROUGH 1977

INTRODUCTION

Bioluminescence is the emission of light by living organisms. Although the best known example is the firefly, many other creatures also luminesce. These are found on land, in fresh water, or in salt water, but the greatest number and diversity are found in salt water. It has been estimated that in the deep ocean, where sunlight never penetrates, possibly 70% of the species and 90% of the individuals are luminous. Luminescence in the sea is not confined to the depths, for not only do some luminous species migrate to near the surface at night, but there are also many other luminous species living near the surface or in shallow water.

When luminescent organisms congregate near the surface in sufficiently large numbers, luminous displays occur. These displays can be classified into several categories according to their appearance. First is white water or milky seas, in which a large area of ocean, frequently from horizon to horizon, appears as a sheet of steadily glowing light. Smaller patches of ocean may also appear to be luminous. These patches may seem to contract and expand, to glow steadily, or to glow intermittently. Sometimes they seem to travel at high speeds until out of sight. Finally, large areas of ocean may sparkle with rapidly scintillating point sources of light. These types of displays occur without apparent stimulation of luminescence on the part of the observer.

Luminous displays of the above character are sufficiently striking and uncommon that when they are observed they are usually reported. Rarer and even more spectacular displays exist, however. One of these is undulating waves of light, in which rapidly moving bands of light alternating with bands of darkness appear to travel from horizon to horizon. A second rare display is the *phosphorescent wheel*, in which alternating arms of light and darkness appear to rotate around a central point, similar to a fireworks pinwheel. Sometimes several wheels can be seen simultaneously. Finally *bubbles* of luminescence occasionally are seen. These are balls of light which appear to rise from the depths and burst against the sea surface.

In spite of the spectacular nature of these bioluminescence displays, in no case are the causes known. No chemical or physical studies of the sea water or atmosphere at the surface have been made during a display. Few organisms have been collected during one. Most of the observations have been made by seamen or travellers, not scientists. Many of the observers have been members of the U.S. Navy. These observations, along with other widespread reports, have created a long-standing interest in bioluminescence in the Navy. Furthermore, the Navy's interest goes beyond displays. A luminous display can occur only

where there is a sufficiently large concentration of luminous organisms to emit light visible to the naked eye. Such large concentrations are uncommon. However, luminous organisms are common in the ocean and, when disturbed, will emit light that can be detected using instruments. The most common instruments used for this purpose are bathyphotometers and low light level image intensifiers (LLLII's).

Bathyphotometers are of two kinds: passive and active. Passive bathyphotometers consist of one or more photocells exposed unshielded to the ocean. They record any spontaneous bioluminescence within their field of view, and also any other light in the water, such as sunlight or moonlight penetrating from above. An active bathyphotometer consists of a photocell looking into an enclosed, shielded chamber. Sea water containing organisms is pumped into the chamber, and the turbulence so generated stimulates any luminous organisms present to flash or glow. This active process is advantageous in that it does not record extraneous light, but disadvantageous in that only small weak-swimming organisms pass into the chamber. Neither kind of bathyphotometer, by itself, can be used to identify the bioluminescent organisms whose light they record.

LLLII's are among the newest tools for detecting bioluminescence in the field. Developed from the Starlight Scope first used in Vietnam, their technology has been improved in less than a decade until now they can enhance light intensity by up to a factor of 100,000. A LLLII customarily consists of a closed-circuit television camera and lens, a TV monitor, and a video tape recorder. The TV camera includes an image-intensification tube. The greatest enhancement can currently be achieved using a modified silicon intensifiedtarget tube called an ISIT. Earlier models used an ordinary camera coupled to a starlight scope, or a secondary electron conduction (SEC) vidicon tube. A LLLII system of this nature is described by Roithmayr (1970) and Roithmayr and Wittmann (1972). This system has been mounted in an airplane and used to detect schools of commercial fish moving through areas containing luminous plankton in the Gulf of Mexico, the Gulf of Maine, off the coast of Southern California, and near Aberdeen, Scotland (F. Wittmann, personal communication). Results of these tests and pictures of fish schools taken at night are presented in Roithmayr (1970), (1971), Drennan (1969), (1971), and Stevenson (1975). In addition, an identical system has been used off the coast of Southwest Africa to detect fish schools for commercial fishermen. These results can be seen in Cram (1972), (1973), (1974), and Cram and Hampton (1976).

Luminous marine organisms have achieved varying degrees of control over their luminescence. At one end of the scale are luminous bacteria, which have no control over their luminescence and which glow continuously. At the other end are fish and squids, which have achieved nearly complete purposeful control. In between are most of the luminous planktonic organisms, which automatically respond to certain kinds of external stimulation by luminescing. In the laboratory, many luminous marine organisms can be stimulated to emit light by chemical, electrical, mechanical, or photic means. At sea, luminous displays are most commonly stimulated mechanically or photically. Ships moving through water containing luminous organisms are a frequent cause of mechanically stimulated displays. The turbulence caused by the ship's passage causes glowing bow waves and wakes. The glowing wakes often extend a distance equal to several times the ship's length. Rough surface conditions and moving schools of fish are other common causes of mechanically stimulated displays. Photically stimulated displays can be triggered by shining a lantern or flashlight briefly into the water. When this is done large areas of water often flash in response. Furthermore, if organisms in one area are mechanically disturbed until they flash, organisms

TABLE 1

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|---------|---------------------|-------------------------------------|---------------------------------|---|---------------------------------|--|--|----------------------------------|---------------------------------|---|---------------------------------|---|---------------------------------------|--|---|--|--|--|--|--|
| | Reference | Nicol, 1962 | Tett, 1969a | Seliger, Biggley & Swift, 1969 | Tett, 1969a | Seliger, Biggley & Swift, 1969 | Tett, 1969a | Tett, 1969a | Tett, 1969a | Tett, 1969a | Tett, 1969a | Seliger, Biggley & Swift, 1969 | Eckert, 1966 | Swift, Biggley & Seliger, 1973 | Swift, Biggley & Seliger, 1973 | Swift, Biggley & Seliger, 1973 | Nicol, 1958c | Nicol, 1958c | Nicol, 1958c | Nicol, 1958c |
| | Intensity | 104 quanta s ⁻¹ per cell | 7.8×10^{-9} W per cell | 2.3×10^{9} quanta s ⁻¹ per cell | 1.2×10^{-9} W per cell | $5.6	imes10^9$ quanta s $^{-1}$ per cell | 7.8 \times 10 ⁻⁹ W per cell | 13.2×10^{-9} W per cell | 3.6×10^{-9} W per cell | $5.6 \times 10^{-9} \text{ W per cell}$ | 3.4×10^{-9} W per cell | $8.0 	imes 10^{10}$ quanta s ⁻¹ per cell | $2.1 	imes 10^{-7} 	ext{ W per cell}$ | 1.1×10^{10} quanta s ⁻¹ per cell | $1.2 	imes 10^{11}$ quanta s ⁻¹ per cell | 1.8×10^{11} quanta s ⁻¹ per cell | $5.3 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | $9.5 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | $0.4 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | $9.3 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ |
| TABLE 1 | Peak wavelength, nm | 470-500 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 474 | 474 | 474 | | 1 | ı | 1 |
| | Species | I | Polykrikos schwartzii | Gonyaulax polyedra | G. catenata | Pyrodinium bahamense | Peridinium depressum | P. divergens | P. ovatum | P. pallidum | P. steinii | Dissodinium (Pyrocystis) lunula | Noctiluca scintillans (miliaris) | Pyrocystis acuta | P. fusiformis | P. notiluca | Cytocladus major and Aulosphaera triodon | Colobonema sericeum | Crossota alba | Aeginura grimaldii |
| | Group | Bacteria | Dinoflagellates | | | | | | | | | | | | | | Radiolaria | Hydrozoa | | |

outside the area of initial disturbance frequently flash in response to that light, thereby greatly extending the luminescent area.

Congregations of luminous organisms occur more frequently in some places and seasons than in others. However, there have been few systematic studies of this variability. The distribution and occurrence of luminous displays have been discussed by several authors: [Kalle (1960), Staples (1966), Turner (1965), (1966), Verploegh (1968)]. Since 1966 our knowledge of the biology, physiology and biochemistry of various species of luminous marine organisms has grown considerably. Some of these advances, along with several recent observations of displays, are outlined by Herring (1976b). This report attempts to update the reports of Staples and Turner, to map reports of the occurrence of luminous organisms in areas where no displays have been reported, and to present data gathered on five cruises by the Naval Research Laboratory on the distribution and occurrence of luminescence in the ocean.

MATERIALS AND METHODS

The data in this paper on the occurrence and distribution of bioluminescence at sea since 1966 are presented as points on a series of maps. Each point represents at least one observation at that geographic location. An observation is considered to be either the sighting of luminescence in the water by eye or by a LLLII, the detection of bioluminescence near the surface by a bathyphotometer lowered into the water, or the catching and identification of known luminous organisms by plankton tows.

The majority of observations were gleaned from a literature search of papers published during or after 1966. While it is impossible to acknowledge each observation plotted on the map, every paper from which an observation was taken is listed in the bibliography. An attempt has been made to present the data seasonally. Any reports too vague to allow determination of the season have been omitted, with the exception of Indian Ocean reports for the northeast monsoon. Reports of luminescence during the northeast monsoon have been arbitrarily placed during January or February, unless the exact date was mentioned, even though the monsoon period covers December as well. Reports of luminescence attributed to fish, cephalopods, and benthic organisms have been deliberately omitted on the grounds that these organisms do not contribute to displays of the type to be detected using a LLLII. Two exceptions are hereby noted. The squid Watasenia scintillans at certain times of the year appears off the north coast of Honshu, Japan, in large enough numbers to cause displays. Second, the teleost fish Photoblepharon and Anomalops found in the Red Sea, Indian Ocean, and South Pacific, school near the surface and create displays. Displays due to these three organisms have been mapped.

Colonies of luminous bacteria have been isolated from sea water from many locations and grown on plates. Luminous bacteria have long been suspected of causing displays, especially when the light glows steadily. However, no display has been specifically shown to be due to luminous bacteria. In spite of the widespread occurrence of luminous bacteria in the ocean, and the suspicion that they cause displays, no locations at which only luminous bacteria were reported have been included on the maps. It has been shown [Nealson, Platt and Hastings (1970), Nealson, Eberhard and Hastings (1972), Eberhard (1972)] that luminous bacteria release into their surroundings a substance that induces the synthesis of luciferase. Fairly high concentrations are necessary to induce synthesis. When the

TABLE 1 — Continued

| Group | Species | Peak wavelength, nm | Intensity | Reference |
|-----------------------|---------------------------|---|---|--------------------------------------|
| (Hydrozoa—Cont.) | Aequoria forskalea | 508 | l | Morin & Hastings, 1971 |
| Siphonophora | Vogtia glabra | 470 | $1.2 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958c |
| | V. spinosa | 470 | $3.2 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958c |
| | Rosacea plicata | ı | $13.7 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958c |
| | Hippopodius hippopus | l | $4.2 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958c |
| Scyphozoa | Atolla wyvillei | 470 | 2×10^{-9} Wm ⁻² at 1 m | Nicol, 1958c |
| | Periphylla periphylla | l | $0.68 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| Anthozoa | Pennatula phosphorea | 510 | $62.8 \times 10^{-15} \text{ Jm}^{-2}$ | Nicol, 1958b |
| | Virgularia mirabilis | 1 | $12 \times 10^{-10} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958b |
| | Renilla reniformis | 509 | ı | Cormier, Hori & Anderson, 1974 |
| Ctenophora | Beroë ovata | 510 | 85×10^{-9} Wm ⁻² at 1 m | Nicol, 1958c |
| | Mnemiopsis leidyi | 490 | $1.9 \times 10^{-7} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1962 |
| Polychaeta | Harmothoë langirelis | 515 | ı | Nicol, 1957a |
| | Polynoë scolopendrina | 515 | ı | Nicol, 1957a |
| | Acholoë astericola | l | $1.11 \times 10^{-10} \; \mathrm{Jm^{-2}}$ | Nicol, 1958a |
| | Lagisca extenuata | l | $1.8 \times 10^{-12} \mathrm{Jm^{-2}}$ | Nicol, 1958a |
| | Odontosyllis enopla | 507 | | Cormier & Totter, 1964 |
| | Chaetopteris variopedatus | 465 | I | Nicol, 1957b |
| Lamellibranchiata | Pholas dactylus | 480 | l | Cormier & Totter, 1964 |
| Cephalopoda | l | from blue to red, depending on species | ſ | Harvey, 1952 |
| Crustacea (Ostracoda) | Cypridina hilgendorfii | 462 | i | Shimomura, Johnson & Masugi, 1969 |
| Crustacea (Copepoda) | Metridia lucens | 1 | $5.9 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | | | | |

TABLE 1 — Continued

| Group | Species | Peak wavelength, nm | Intensity | Reference |
|--------------------------|----------------------------|---------------------|--|----------------------|
| Crustacea (Copepoda)— | M. longa | I | 9.8 × 10-9 Wm-2 at 1 m | Clarke, et al., 1962 |
| (Cont.) | M. princeps | ı | 21.4×10^{-9} Wm ⁻² at 1 m | Clarke, et al., 1962 |
| | Pleuromamma robusta | 1 | $0.11 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | P. xiphias | I | $2.9 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | Lucicutia grandis | ı | $1.6 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | Euaugaptilus magnus | ı | $1.5 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | Heterorhabdus spp. | I | $0.27 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Clarke, et al., 1962 |
| | Heterostylites longicornis | i | 0.27×10^{-9} Wm ⁻² at 1 m | Clarke, et al., 1962 |
| Crustacea (Decapoda) | Acanthephyra purpuria | i | $8.2 \times 10^{-11} \text{ Wm}^{-2} \text{ at 1 m}$ | Nicol, 1958c |
| | A. pelagica | ı | 25×10^{-9} Wm ⁻² at 1 m | Clarke, et al., 1962 |
| Crustacea (Euphausiacea) | Euphausia pacifica | 476 | $2.0 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Kampa & Boden, 1957 |
| | Thysanoëssa raschii | 476 | 1 | Boden & Kampa, 1959 |
| | Meganyctiphanes norvegica | 476 | 0.3×10^{-9} Wm ⁻² at 1 m | Clarke, et al., 1962 |
| Urochordata | Pyrosoma atlanticum | 482 | $40 \times 10^{-9} \text{ Wm}^{-2} \text{ at 1 m}$ | Kampa & Boden, 1957 |
| Teleostii | Searsia schnakenbecki | ŀ | $4.3 \times 10^{-9} \text{ Wm}^2 \text{ at 1 m}$ | Nicol, 1958c |
| | S. koefoedi | I | 28×10^{-9} Wm ⁻² at 1 m | Nicol, 1958c |
| | Myctophum punctatum | 470 | 52×10^{-11} Wm ⁻² at 1 m | Nicol, 1958c |
| | Apogon ellioti | 460 | 1 | Sie, et al., 1961 |
| | Porichthys spp. | | $1.4 \times 10^{-9} \text{ W}$ | Baguet & Case, 1971 |

Systematic studies have been undertaken in two regions—the Indian Ocean, as part of the International Indian Ocean Expedition, and the Barents Sea. Unfortunately, the scientists involved in these studies were not concerned with bioluminescence as such, but were simply looking at the distribution of various planktonic organisms. Nevertheless, the maps covering these regions (Figs. 5, 12, and 14) show that bioluminescent organisms occurred throughout both areas and in the Indian Ocean throughout the year as well. If such systematic studies were performed in other oceans, it is likely that similar results could be expected.

CONCLUSIONS

The reported observations of bioluminescence and bioluminescent organisms have been largely the result of chance. The location of sampling sites has been largely a matter of opportunity. But even from these facts, it can be seen that luminescence is extremely widespread. Dinoflagellates and euphausiids appear to be the most widely distributed causative organisms. The current development of LLLII's permits luminescence to be detected even when it is not visible to the naked eye. This new tool has the potential for greatly increasing the information to be derived from temporal and areal studies, and, when airborne, provides an opportunity for rapid synoptic observations.

ACKNOWLEDGMENTS

I wish to thank Robert Staples of the Naval Oceanographic Office, Catherine Gordon of the Naval Oceanographic Research and Development Agency, Dr. Frank Wittmann of the National Marine Fisheries Service, and Lt. James Carlson of the Naval Postgraduate School in Monterey, California, all of whom were especially diligent in relating to me not only their sightings but also the observations made by others, of which I might not otherwise have been informed.

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the filter is given by the modified Householder transform previously described, and the terms are rearranged to obtain a more desirable form. This completes the filter operation except for forming the smoothed estimate and the covariance if desired from the transformed state and the covariance factors.

SUMMARY

The SRIF filter is a numerical means of solving the Kalman-filter equations. In this report the SRIF filter was modified to accommodate LDL factorizations of the covariances rather that the usual LL factorizations. This factorization required that the Householder algorithm be modified and required a small manipulation of the results after transforming. Under a special case the prediction process was shown to be quite simple using the LDL' factorization.

The reason for investigating the SRIF filter using LDL' factorizations was to try to eliminate the square-root operations found in the SRIF filter. Although the square-root operations using LDL' factorization now do not appear in the prewhitening process, they still are necessary in the modified Householder algorithm. Consequently the results are not as strong as was first hoped for. An interesting result does occur in the use of a fading memory: Only the diagonal elements D of the LDL' factorization need be weighted rather than the entire covariance matrix.

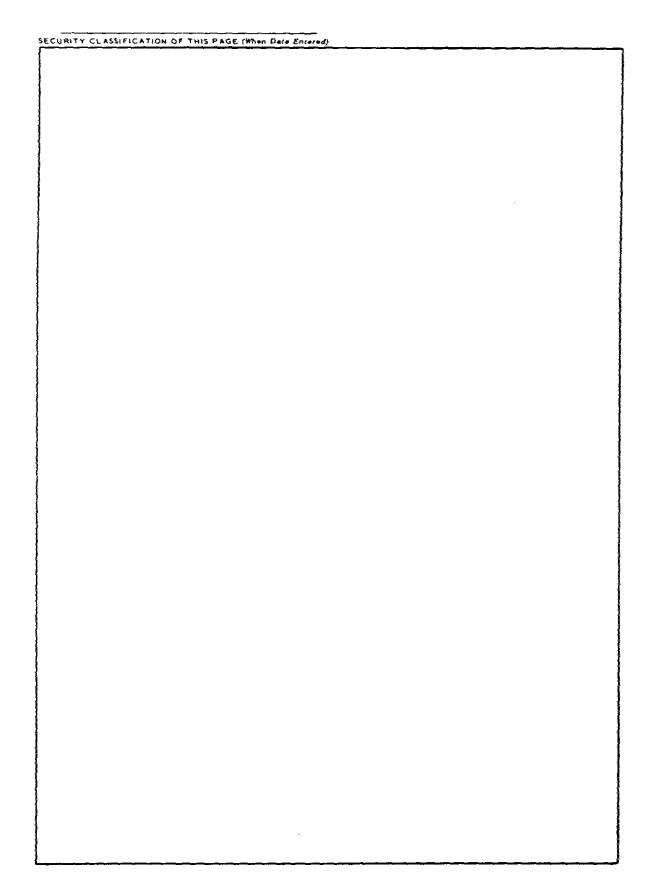
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1. G. J. Bierman, Factorization Methods for Discrete Sequential Estimation, Academic, New York, 1977.

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A MODIFIED SRIF FILTER USING LDL' FACTORIZATIONS

INTRODUCTION

The problem of estimating a set of parameters or variables from a set of measurements has long been of interest. Kalman in the early sixties provided a simple recursive estimation procedures by introducing the concept of state and state transition. This procedure in some instances provided simpler implementation than batching techniques. Since Kalman's work a number of numerical procedures have been developed. An excellent account of these procedures as well as historical notes can be found in Bierman's book [1]. Two basic techniques described in Ref. 1 are the square-root information filter (SRIF filter) and the UDU filter (where UDU should actually be UDU', with U being an upper triangular matrix and D being a diagonal matrix). In both cases the data are prewhitened using Cholesky factorization. The SRIF filter is then based on the Householder transform. The UDU filter is based on a Cholesky factorization of the smoothed covariance update using one measurement at a time and the modified Gram Schmidt for updating the predicted covariance. These numerical techniques are claimed to have better numerical stability than direct use of the Kalman filter equations and may be more amenable to hardware implementation.

In Ref. 1 the SRIF filter described used a Cholesky factorization of the covariance matrix of the form of a triangular matrix times the transpose of the same triangular matrix. This report is concerned with reformulating the SRIF filter in terms of a Cholesky factorization of the covariance matrix using a triangular matrix times a diagonal matrix times the transpose of the same triangular matrix, where the diagonal elements of the triangular matrix are 1. The reason for changing the factorization is to attempt to remove some of the square-root operations.

The following section briefly reviews the Kalman filter. The SRIF filter is next derived using the alternate factorization. The properties of a modified Householder algorithm which are necessary for the SRIF-filter mechanization are shown. The prediction process is shown for the case of no process noise, and an exponential time weighting into the past is incorporated. Finally the entire algorithm is written out and examined.

MODIFIED SRIF FILTER

The SRIF filter is a numerical method of implementing the Kalman filter [1]. The Kalman filter is obtained from modeling the process as state equations, defining a measurement procedure, and best-estimating the states of the systems. The state equation and measurement process are defined as

$$X(k) = \Phi(k) \ X(k-1) + \Gamma(k) \ W(k)$$

and

$$X_M(k) = H(k) X(k) + V(k).$$

Manuscript submitted February 28, 1978.

where it is desired to best-estimate the *n*-by-1 state vector X(k). The remaining quantities are *n*-by-*n* state transition matrix $\Phi(k)$, an *n*-by-*p* matrix $\Gamma(k)$, an *m*-by-*n* measurement matrix H(k), and an *m*-by-1 measurement vector $X_M(k)$, with W(k) and V(k) being Gaussian noises with the following properties:

$$E[W(k)] = 0,$$

$$E[W(k) | W'(j)] = S(k) | \delta_{jk},$$

$$E[V(k)] = 0,$$

$$E[V(k) | v(j)] = Q(k) | \delta_{jk},$$

and

$$E\Big[W(k)\ V(j)\Big]=0,$$

in which

 $\delta_{jk} = 1$ when j = k and 0 otherwise.

The covariance matrices S(k) and Q(k) are of dimension p by p and m by m, respectively.

The best estimate of X(k), denoted by $\tilde{X}(k)$ in the standard Kalman-filter format, is

$$\tilde{X}(k) = \hat{X}(k) + K(k) \left[X_M(k) - H(k) \hat{X}(k) \right],$$
 (1)

where K(k) is the filter gain, given by

$$K(k) = \tilde{P}(k) H'(k) Q^{-1}(k).$$
 (2)

In equation (2) $\tilde{P}(k)$ is the smoothed covariance matrix, given by

$$\tilde{P}^{-1}(k) = \hat{P}^{-1}(k) + H'(k) \ Q^{-1}(k) \ H(k). \tag{3}$$

In equation (3) $\hat{P}(k)$ is the predicted covariance matrix, with

$$\hat{P}(k+1) = \Phi(k+1) \ \tilde{P}(k) \ \Phi'(k+1) + \Gamma(k+1)$$

$$S(k+1) \ \Gamma'(k+1). \tag{4}$$

The prediction is

$$\hat{X}(k+1) = \Phi(k+1) \ \tilde{X}(k). \tag{5}$$

The filter operates in a predict-and-correct fashion. This suggests the following simple derivation.

Equation (1) is the least-square estimate between the prediction and the measurement at the kth sample, which is obtained by minimizing the cost function

$$J(k) = \left[\hat{X}(k) - X(k)\right]' \hat{P}^{-1}(k) \left[\hat{X}(k) - X(k)\right] + \left[X_M(k) - HX(k)\right]' Q^{-1}(k) \left[X_M(k) - HX(k)\right]$$
(6)

with respect to X(k). The value of X(k) which minimizes X(k), denoted by $\tilde{X}(k)$, is the best estimate of X(k) and is given in equations (1) through (3). When the best estimate of $\tilde{X}(k)$

is given, the best prediction is simply equation (5) with the covariance of (4). The process is then simply repeated recursively with equations (4) and (5) being the prediction and equations (1) through (3) being the correction.

The SRIF filter is a means of implementing the Kalman filter which depends heavily on Cholsky decomposition and the Householder matrix triangulation algorithm [1]. The Cholsky decomposition is performed on a symmetric positive-definite matrix by factoring it to the product of a lower triangular matrix L and its transpose:

$$Q = L L'$$

and

$$Q^{-1} = (L')^{-1} L^{-1}$$
.

The algorithm for obtaining L, found in Ref. 1, is

$$\mathbf{\ell}_{jj} = \sqrt{q_{jj}}, \quad j = 1, \quad n - 1,$$

$$\mathbf{l}_{kj} = q_{kj}/\mathbf{l}_{jj}, \quad k = j + 1, ..., n,$$

and

$$q_{ik} = q_{ik} - l_{ij} l_{kj}, \quad k = j + 1,..., \quad n \text{ and } i = k, ..., \quad n.$$

In this report the LDL' factorization described in Ref. 1 is used to construct the SRIF-like filter rather than using the L L' factorization. The algorithm for obtaining the LDL' factorization is

$$O = L D L'$$

and

$$Q^{-1} = (L')^{-1} D^{-1} L^{-1}$$

where

$$\mathbf{l}_{jj} = 1, \quad j = 1, \dots, n-1,$$
 $d_j = q_{jj},$
 $\mathbf{l}_{kj} = q_{kj}/d_j, \quad k = j+1, \dots, n,$

and

$$q_{ik} = q_{ik} - l_{ij} l_{kj} d_j$$
, $k = j + 1$, ..., n and $i = k$, ..., n .

The matrix L is lower triangular in form and has diagonal elements of 1. The matrix D is a diagonal matrix with diagonal elements of d_i .

The derivation of a SRIF filter using the LDL' factorization proceeds as follows. The cost function in equation (6) can be written as

$$J = (\hat{X} - X)' \hat{R} \hat{D} \hat{R}' (\hat{X} - X) + (X_M - HX)'$$
$$(L')^{-1} D_M^{-1} L^{-1} (X_M - HX), \tag{7}$$

where the k denoting sample number has been dropped for notational convenience, $\hat{P}^{-1}(k)$ is factored into \hat{R} \hat{D} \hat{R}' , and Q(k) is factored into L D_M L' (so that $Q^{-1}(k) = (L')^{-1}$ D_M^{-1} L^{-1}). Equation (7) can be rewritten as

$$J = (\hat{Z} - \hat{R}'X)' \hat{D}(\hat{Z} - \hat{R}'Z) + (Z_M - H_W X)' D_M^{-1}(Z_M - H_W X),$$
 (8)

where

$$\hat{Z} = \hat{R}'X,$$

$$Z_M = L^{-1}X_M,$$

and

$$H_W = L^{-1}H.$$

Equation (8) can be rewritten more compactly as

$$J = \left[\begin{bmatrix} \hat{R}' \\ H_W \end{bmatrix} X - \begin{bmatrix} \hat{Z} \\ Z_M \end{bmatrix} \right] \begin{bmatrix} \hat{D} & 0 \\ 0 & D_M^{-1} \end{bmatrix} \begin{bmatrix} R' \\ H_W \end{bmatrix} X - \begin{bmatrix} \hat{Z} \\ Z_M \end{bmatrix}$$
 (9)

With the notation

$$D = \begin{bmatrix} \hat{D} & 0 \\ 0 & D_M^{-1} \end{bmatrix},$$

the cost function is unaltered if an orthogonal transform T, where T'D T = D, is multiplied by the new resulting vector in equation (9). Consequently use of

$$\begin{bmatrix} \hat{R}' \\ H_W \end{bmatrix} X - \begin{bmatrix} \hat{Z} \\ Z_M \end{bmatrix} = C$$

in J = C' D C yields the same cost as

$$J = C'T'D T C.$$

In addition, if T, which is a n-plus-m square matrix, is chosen such that

$$T\begin{bmatrix} \hat{R}' \\ H_W \end{bmatrix} = \begin{bmatrix} \overline{R}' \\ 0 \end{bmatrix} \tag{10}$$

and

$$T\begin{bmatrix} \hat{Z} \\ Z_M \end{bmatrix} = \begin{bmatrix} \overline{Z} \\ e \end{bmatrix},\tag{11}$$

the cost then becomes

$$J = (\overline{R}'X - \overline{Z})' \hat{D}(\overline{R}'X - \overline{Z}) + e'D_M^{-1} e.$$
 (12)

By inspection the least-square estimate of X is

$$\overline{R}'\widetilde{X} = \overline{Z}, \text{ or } \widetilde{X} = (\overline{R}')^{-1}\overline{Z},$$
 (13)

A Modified SRIF Filter Using LDL Factorizations

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May 15, 1978



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the minimum value of the cost J is $e'D_M^{-1}e$, and the smoothed covariance is $\tilde{P}(k) = \overline{R}'D$ \overline{R} . For simplification equation (10) is augmented to equation (11) yielding

$$T\begin{bmatrix} \hat{R}' & \hat{Z} \\ H_W & Z_M \end{bmatrix} = \begin{bmatrix} \overline{R}' & \overline{Z} \\ 0 & e \end{bmatrix}$$
 (14)

Later it will be shown that the smoothed covariance factor \overline{R} does not have all 1's on the diagonal elements as the factors \hat{R} and L did. This can be modified by relating the factors \overline{R} and \hat{D} to new factors \tilde{R} and \tilde{D} , where \tilde{R} has diagonal elements of 1. This can be shown by rewriting the cost of equation (12) as

$$J = (X - \tilde{X})' \, \overline{R} \, \hat{D} \, \overline{R}' \, (X - \tilde{X}) + e' D_M^{-1} \, e.$$

Since the smoothed covariance can be rewritten as $\tilde{P} = \overline{R} \ \hat{D} \ \overline{R}'$ or $\tilde{P} = \tilde{R} \ \tilde{D} \ \tilde{R}$, the cost function can be rewritten with either way unaltered. The relation can be found by noting the 2-by-2 example

$$\begin{bmatrix} \overline{r}_{11} & 0 \\ \overline{r}_{21} & \overline{r}_{22} \end{bmatrix} \begin{bmatrix} \hat{d}_1 & 0 \\ 0 & \hat{d}_2 \end{bmatrix} \begin{bmatrix} \overline{r}_{11} & \overline{r}_{21} \\ 0 & \overline{r}_{22} \end{bmatrix}$$

which can be rewritten as

$$\begin{bmatrix} 1 & 0 \\ \overline{r}_{21}/\overline{r}_{11} & 1 \end{bmatrix} \begin{bmatrix} \overline{r}_{11} & 0 \\ 0 & \overline{r}_{22} \end{bmatrix} \begin{bmatrix} \hat{d}_{1} & 0 \\ 0 & \hat{d}_{2} \end{bmatrix} \begin{bmatrix} \overline{r}_{11} & 0 \\ 0 & \overline{r}_{22} \end{bmatrix} \begin{bmatrix} 1 & \overline{r}_{21}/\overline{r}_{11} \\ 0 & 1 \end{bmatrix}$$
(15)

Combining terms in equation (15) yields

$$\begin{bmatrix} 1 & 0 \\ \overline{r}_{21}/\overline{r}_{11} & 1 \end{bmatrix} \begin{bmatrix} \hat{d}_1 \overline{r}_{11}^2 & 0 \\ 0 & \hat{d}_2 \overline{r}_{22}^2 \end{bmatrix} \begin{bmatrix} 1 & \overline{r}_{21}/\overline{r}_{11} \\ 0 & 1 \end{bmatrix}$$

This is the desired factored form \tilde{R} \tilde{D} \tilde{R}' . The algorithm can easily be generalized to yield

$$\tilde{d}_i = \hat{d}_i \, \bar{r}_{ii}^2, \quad i = 1, ..., n,$$
 (16)

and

$$\tilde{r}_{ji} = \overline{r}_{ji}/\overline{r}_{ii}, \quad j = i, ..., n.$$
 (17)

The least-square estimate of \tilde{X} in equation (13) is given by $\overline{R}'\tilde{X}=\overline{Z}$, which is also altered into the form

$$\tilde{R}'\tilde{X} = \tilde{Z}.\tag{18}$$

By example again, equation (13) can be written as

$$\begin{bmatrix} \overline{r}_{11} & \overline{r}_{12} \\ 0 & \overline{r}_{22} \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \end{bmatrix} = \begin{bmatrix} \overline{z}_1 \\ \overline{z}_2 \end{bmatrix},$$

which can be written as

$$\begin{bmatrix} \overline{r}_{11} & 0 \\ 0 & \overline{r}_{22} \end{bmatrix} \begin{bmatrix} 1 & \overline{r}_{21}/\overline{r}_{11} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \bar{x}_1 \\ \bar{x}_2 \end{bmatrix} = \begin{bmatrix} \overline{z}_1 \\ \overline{z}_2 \end{bmatrix},$$

which in turn can be rewritten as

$$\begin{bmatrix} 1 & \overline{r}_{21}/\overline{r}_{11} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \bar{x}_1 \\ \bar{x}_2 \end{bmatrix} = \begin{bmatrix} z_1/\overline{r}_{11} \\ z_2/\overline{r}_{22} \end{bmatrix}. \tag{19}$$

Equation (19) is the desired form (18), where

$$\tilde{z}_i = \tilde{z}_i/\tilde{r}_{ii}, \quad i = 1, \dots, n. \tag{20}$$

As a summary of the preceding results, the transform T is applied to the augmented matrix equation (14) and the desired factored form is obtained by applying equation (16), (17), and (20). We next consider how the matrix transform T which triangulates a matrix with the property T D'T = D is obtained.

MODIFIED HOUSEHOLDER TRANSFORM

The elementary Householder transform given in Ref. 1 is obtained as follows. Let the vector U be normal to the plane U_1 . An arbitrary vector Y can be represented by

$$Y = (Y'\hat{U}) \hat{U} + V, \tag{21}$$

where $\hat{U} = U/\sqrt{U'U}$ and V is that part of Y that is orthogonal to U. The reflection of Y, denoted by Y_r , in the plane U_{\parallel} is

$$Y_{*} = -(Y'\hat{U})\hat{U} + V \tag{22}$$

and is represented in Fig. 1. Eliminating V from equations (21) and (22) yields

$$Y_r = Y - 2 \frac{(Y'U)}{(U'U)} U = (I - \beta UU') Y = TY,$$
 (23)

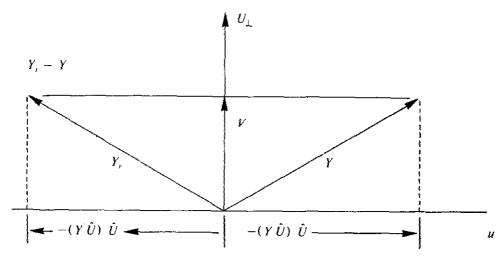


Fig. 1 - Geometry of the Householder algorithm

where β is defined as $\beta = 2/U'DU$. The matrix T is an elementary Householder transform with properties T = T' and $T^2 = I$, and it can be shown to triangulate a matrix.

To obtain the desired results required in the previous section, the dot products of equation (23) are modified by a diagonal matrix D to yield

$$Y_r = Y - 2 \frac{(Y'DU)}{(U'DU)} U = (I - \beta UU'D) Y = TY.$$
 (24)

Four properties are given and proved. Property 1 is

$$T' = T$$
 (T is symmetric).

Since, from equation (35),

$$T' = (I - \beta UU'D)'$$

$$= (I - \beta D'UU')$$

$$= (I - \beta DUU'),$$

the proof that T' = T requires showing that DUU' = UU'D. If DUU' = UU'D, then

$$U'(DUU') U = U'(UU'D) U$$

οг

$$(U'DU)\ (U'U) = (U'U)\ (U'DU),$$

which is an identity. QED.

Property 2 is

$$T' DT = D.$$

Since

$$T'DT = (I - \beta UU'D)' D (I - \beta UU'D)$$

$$= (I - \beta DUU') D (I - \beta UU'D)$$

$$= (D - \beta DUU'D) (I - \beta UU'D)$$

$$= D - 2\beta DUU'D + \beta^2 DUU'DUU'D$$

$$= D - 2\beta DU[U'D - (\beta/2) U'DUU'D],$$

the proof requires showing that

$$U'D - (\beta/2) U'DUU'D = 0$$

or that

$$U'D - \frac{2}{2(U'DU)} U'DUU'D = 0$$

or that

$$U'DUU'D - U'DUU'D = 0.$$

which is an identity. QED.

To express properties 3 and 4, the following notation is introduced:

$$\sigma = \sqrt{\frac{Y'DY}{d_1}}, \text{ where } D = \begin{bmatrix} d_1 & 0 & 0 & 0\\ 0 & d_2 & 0 & 0\\ 0 & 0 & \dots & 0\\ 0 & 0 & 0 & d_n \end{bmatrix}$$

and

$$U = \begin{bmatrix} u_1 \\ u_2 \\ \dots \\ \mu_n \end{bmatrix}$$

in which

$$u_1 = y_1 + \sigma,$$

$$u_2 = y_2,$$

$$u_3 = y_3,$$

and

$$u_N = y_N$$

Property 3 is

$$\beta = \frac{2}{U'DU} = \frac{1}{d_1 \sigma u_1},$$

which is proven by writing

$$\frac{2}{U'DU} = \frac{2}{(y_1 + \sigma)^2 d_1 + y_2^2 d_2 + \dots + y_n^2 d_n}$$

$$= \frac{2}{2y_1 \sigma d_1 + \sigma^2 d_1 + (y_1^2 d_1 + y_2^2 d_2 + \dots + y_n^2 d_n)}$$

$$= \frac{2}{2y_1 \sigma d_1 + \sigma^2 d_1 + \sigma^2 d_1}$$

$$= \frac{1}{d_1 \sigma (y_1 + \sigma)} = \frac{1}{d_1 \sigma u_1}.$$

QED.

Property 4 is

$$Y_r = TY = \begin{bmatrix} y_{rl} \\ y_{r2} \\ \dots \\ y_{rn} \end{bmatrix} = \begin{bmatrix} -\sigma \\ 0 \\ \dots \\ 0 \end{bmatrix}$$

The proof is as follows. From equation (35)

$$TY = Y - 2\frac{(Y'DU)}{U'DU}U$$

$$= Y - \frac{\left[y_1(y_1 + \sigma)d_1 + y_2^2d_2 + \dots + y_N^2d_n\right]U}{d_1\sigma u_1}$$

$$= Y - \frac{(y_1\sigma d_1 + \sigma^2 d_1)U}{d_1\sigma u_1}$$

$$= Y - \frac{(y_1 + \sigma)}{u_1}U$$

$$= Y - U$$

$$= \begin{bmatrix} y_1 \\ y_2 \\ \dots \\ y_N \end{bmatrix} - \begin{bmatrix} y_1 + \sigma \\ y_2 \\ \dots \\ y_N \end{bmatrix} = \begin{bmatrix} -\sigma \\ 0 \\ \dots \\ 0 \end{bmatrix}$$

QED. We will use

$$TY = -Y + 2\frac{(Y'DU)}{U'DU}U$$

such that

$$TY = \begin{bmatrix} +\sigma \\ 0 \\ \dots \\ 0 \end{bmatrix}$$

so as to have the convenience of postive diagonal elements in the resulting triangularized matrix. Properties 3 and 4 can be used to triangulate a matrix by applying them on successive columns of the matrix.

The following example illustrates the use of the algorithm:

$$T_1 \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \\ a_{41} & a_{42} & a_{43} \end{bmatrix} = \begin{bmatrix} \sigma_1 & b_{12} & b_{13} \\ 0 & b_{22} & b_{23} \\ 0 & b_{32} & b_{33} \\ 0 & b_{42} & b_{43} \end{bmatrix}$$

where

$$U = \begin{bmatrix} a_{11} + \sigma_1 \\ a_{21} \\ a_{31} \\ a_{41} \end{bmatrix}$$

$$\sigma_1 = \operatorname{sgn} \ a_{11} \sqrt{\left(a_{11}^2 d_1^2 + a_{21}^2 d_2 + a_{31}^2 d_3 + a_{41}^2 d_4\right)/d_1},$$

and

$$b_{ij} = -a_{ji} + \beta \gamma_{lj} u_i$$
, $j = 1, ..., 3$ and $i = 1, ..., 4$,

in which

$$\beta = \frac{1}{d_1 \sigma u_1}$$

and

$$\gamma_{1i} = a_{1j}u_1 + a_{2j}u_2 + a_{2u}u_2 + a_{3j}u_3 + a_{4j}u_4.$$

The process is repeated for each successive submatrix. The next step is

$$\begin{bmatrix} 1 & 0 \\ 0 & T_2 \end{bmatrix} \begin{bmatrix} \sigma_1 & b_{12} & b_{13} \\ 0 & b_{22} & b_{23} \\ 0 & b_{32} & b_{33} \\ 0 & b_{42} & b_{43} \end{bmatrix} = \begin{bmatrix} \sigma_1 & b_{12} & b_{13} \\ 0 & \sigma_2 & c_{23} \\ 0 & 0 & c_{33} \\ 0 & 0 & c_{43} \end{bmatrix}$$

where

$$U = \begin{bmatrix} b_{22} + \sigma \\ b_{32} \\ b_{42} \end{bmatrix}$$

$$\sigma_2 = \operatorname{sgn}(b_{22}) \sqrt{(b_{22}^2 d_2 + b_{32}^2 d_3 + b_{42}^2 d_4)/d_2},$$

and

$$c_{ij} = -b_{ij} + \beta \gamma_{2i} u_{i-1}, \quad j = 2, 3 \text{ and } i = 2, \dots 4,$$

in which

$$\beta = \frac{1}{d_2 \sigma u_1}$$

and

$$\gamma_{2j} = b_{2j}u_1 + b_{3j}u_2 + b_{4j}u_3.$$

In summary, it was shown that the modified Householder algorithm meets the requirements of the modified SRIF filter (T'D T = D, with T triangulating the matrix). A simple means of obtaining the prediction portion of the SRIF filter under an important case is next considered.

PREDICTION PROCESS

The smoothing portion of the Kalman filter using a modified-SRIF-filter implementation updates the factorization of the smoothed covariance and the transformed best estimate. It is desirable to update the prediction process in a commensurable form. Only an important special case is considered: The process noise W(k) is assumed to be zero, and the state transition matrix is assumed to be in the upper triangular form. Equation (4) updating the predicted covariance then becomes

$$\hat{P} = \Phi \ P \ \Phi', \tag{25}$$

where the noise W(k) is removed and the sample k has been dropped for notational convenience. The inverse of (25) is taken, yielding

$$\hat{P}^{-1} = (\Phi')^{-1} \tilde{P}^{-1} \Phi^{-1}. \tag{26}$$

The covariances are replaced with their factorizations

$$\hat{R} \ \hat{D} \ \hat{R}' = (\Phi')^{-1} \ \tilde{R} \ \tilde{D} \ \tilde{R}' \ \Phi^{-1}.$$

which can be rewritten as

$$\hat{R} \hat{D} \hat{R} = (\Phi')^{-1} \tilde{R} \tilde{D} (\Phi^{-1} \tilde{R})'.$$

Since $(\Phi')^{-1} R$ is of the lower triangular form, then

$$\hat{R} = (\Phi')^{-1} \tilde{R} \tag{27a}$$

and

$$\hat{D} = \tilde{D}, \tag{27b}$$

which shows the simple form of updating the factors of the prediction covariance.

The predicted state given by

$$\hat{X} = \Phi \ \tilde{X}$$

from equation (7) is transformed by

$$(\hat{R}')^{-1} \hat{Z} = \Phi(\tilde{R}')^{-1} \tilde{Z},$$

where $\hat{X} = (\hat{R}')^{-1} \hat{Z}$ and $\bar{X} = (\bar{R}')^{-1} \hat{Z}$. Solving for \hat{Z} yields

$$\hat{Z} = (\hat{R}') \Phi(\tilde{R}')^{-1} \tilde{Z}. \tag{28}$$

Substituting \hat{R} from (27a) into (28) yields

$$\hat{Z} = \tilde{Z}$$
.

The transformed smoothed and predicted states are seen to be identical.

Sometimes it is desirable to implement a fading-memory filter by making the smoothed covariance larger. This is accomplished by rewriting equation (26) as

$$\hat{P}^{-1} = (\Phi')^{-1} a \tilde{P}^{-1} \Phi^{-1}$$
.

The parameter is a scalar representing a time fading by

$$a = e^{-t/\tau}.$$

where τ is the time constant and t is time. Equation (27b) is modified, and equations (27a) and (27b) now are

$$\hat{R} = (\Phi')^{-1} \tilde{R}$$

and

$$\hat{D} = \sqrt{a} \ \tilde{D}.$$

and these equations now remain the same under the fading-memory condition.

A functional flow of the filter using the special-case prediction is shown in Fig. 2. The measurement and measurement matrix are first transformed using the factorization of the measurement covariance matrix. For zero process noise and upper-triangular-form state transition matrices, the prediction process is given simply. The transformed predicted and smoothed states are the same, and the covariances are related by a simple transform. The smoothing on

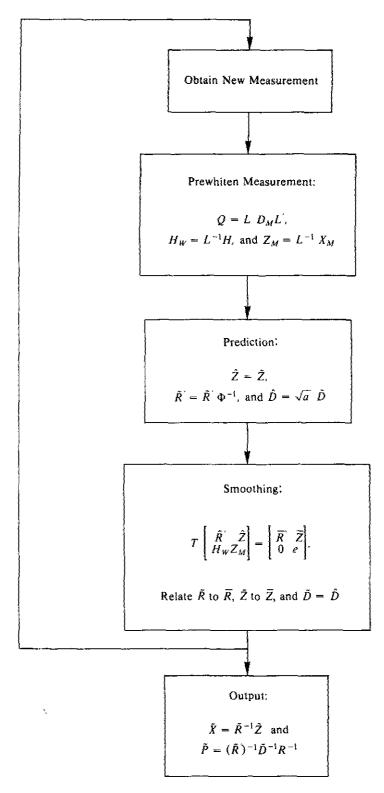


Fig. 2 — Functional flow of the modified SRIF filter using LDL' factorization and a special-case prediction

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NAVAL AIR PROPULSION CENTER TRENTON, NEW JERSEY 08628

(609) 882-1414 + Ext AV 234-1770

| NAME | \underline{CODE} | PHONE | SPECIALTY |
|-------------|--------------------|-------|-------------------------------------|
| Shen, C. N. | MS-2 | 438 | Lasers; IR; Optical Instrumentation |

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Summer 1978 Directory of Navy Electro-Optical Professionals

Electro-Optical Technology Program Office (EOTPO)
Special Projects Organization

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NAVAL AIR TEST CENTER PATUXENT RIVER, MARYLAND 20670

(301) 863-xxxx AV 356-xxxx

| NAME | CODE | PHONE | SPECIALTY |
|---------------------|-------|-------|---|
| Aubertine, P. H. | AT40 | 4776 | P-3 Reliability/ Maintainability |
| Batdorf, R. E. (LT) | SA60 | 3982 | A-7 T&E |
| Cleland, T. (LT) | SA60 | 3982 | A-6 T&E |
| Cohey, A. C. | SA83 | 4713 | A-6 TRAM, E-0 Sensors |
| Hughes, Donald D. | AT51 | 4101 | S-3A/P-3/OV-10 T&E |
| Jewett, C. E. (LT) | SA80 | 4713 | A-6E TRAM, OV-10 |
| Koeniger, Ludwig G. | SA83 | 4713 | E-O Target Complex |
| Krouse, Lynn C. | SA83 | 4713 | E-O Sensors; A-6 TRAM T&E IR Mappers; Reconnaissance Sensors; EOTAG |
| McCoy, Daniel W. | SA83 | 4713 | IRCM T&E A-7 TRAM T&E Reconnaissance Sensors |
| Murphy, Richard C. | SA60A | 3982 | E-0/Attack Weapons Interface |
| Ritter, M. H. | SA42 | 4844 | A-6/A-7 Reliability/ Maintainability |
| Thompson, Robert D. | SA83 | 4226 | E-O T&E IR Mappers |

NAVAIR

NAVAL AIR SYSTEMS COMMAND HEADQUARTERS WASHINGTON, D.C. 20361

(202) 692-xxxx -- AV 222-xxxx (202) 433-xxxx -- AV 288-xxxx

(202) 756-xxxx -- AV 289-xxxx

| NAME | CODE (NAIR) | PHONE | SPECIALTY |
|--------------------------------------|--------------------|-------------------------------|--|
| Anzlone, S. | 510E | 692-8723 | E-O Recçe; EW |
| Apfelbeck, Charles A. | 41124D | 756-1450 | IRCM; Recce; E-O |
| Armbruster, Donald L. Aud, Joseph | 533351A 533354A | 692 - 1738 692-1735 | |
| Beggs, Elizabeth B. | 360 | 692-2510 | E-O R&T TTCP; CCG |
| Burns, J. E. | 52022A | 692-7642 | E-O Technology |
| Caldwell, Donald C. | 53632D | 692-2653 | IR Suppression |
| Cavanaugh, V. P. | 5324 | 692-3948 | Ordnance Fuzing |
| Cosgrove, Edward V. | 533351 | 692-1738 | Avionics/Attack Systems Reconnaissance; EOTAG (Alt) |
| Desmond, Jon L. | 533353B | 692-1739 | E-O Technology |
| Glatt, B. | 03P24 | 692-3023 | Laser Technology; Advanced Weapons Systems |
| Glista, Andrew S. Jr. | 52022G | 692-7640 | E-O Components |
| Gravlin, E. S. | 03P22 | 692-3023 | Advanced Weapons Systems |
| Habayeb, Abdul R. | 03P23 | 692-3023 | Laser Technology; Advanced Weapons Systems |
| Hall, Dorlas R. | 5109C1 | 692-8572 | E-O Missile; WALLEYE- BULLDOG |
| Hardy, Martin E. (CDR) | 5108в | 692-8620 | IR Missile; SIDEWINDER |
| Haskell, Elnathan | 533323 | 692-1743 | A-7E Weapons System |
| Hennessey, R. W. (LCDR) | 5402E | 692-2618 | Airborne Meteorological Equipment |
| Hoffman, Kenneth L. | 533322 | 692-6441 | E-O Missile Control and Guidance |
| Hooper, E. T. | 370D | 692-7414 | E-O Surveillance |
| Jenkins, D. | 53441 | 692-3094 | E-O GSE; Weapons/BULLDOG |

| (202) | 692-xxxx | AV | 222-xxxx |
|-------|------------|--------|----------|
| (202) | 433-xxxx | ΑV | 288-xxxx |
| (202) | 756 - xxxx | ΑV | 289-xxxx |

| NAME | CODE | PHONE | SPECIALTY |
|----------------------|----------------------|---------------|--------------------------------------|
| Johnson, James R. | 533353A | 692-1738 | Avionics/E-O Imaging |
| Ketchum, James H. | 41121A | 756-1400 | Laser Maintenance |
| Kimble, C. (LCDR) | 510E | 692-8720 | E-O Recce; EOW |
| Klein, Lonny E. | 533352B | 692-1738 | Avionics; Attack Systems |
| Kruspe, E. O. | 5108B1 | 692-8678 | IR Missile; SIDEWINDER |
| Luppino, P. | 360D | 692-2511 | EW |
| Macaluso, Mariono P. | 533324A | 692-1741 | A6 Weapons System |
| Malloy, Justin W. | 03P2 | 692-3022 | Advanced Weapons Systems |
| Meth, Martin A. | 41124 | 756-1450 | E-O Maintenance |
| Noel, William T. | 533352A | 692-1737 | Avionics; Recce Sensors |
| Quinn, Paul W. III | 370F | 692-2515 | E-O Surveillance; ESM |
| Regelson, Ephraim | 4115 | 756-1327 | E-O Support/Special Projects |
| Retta, Richard A. | 52022 | 692-7640 | Technical Support; E-O Components |
| Smith, Edward H. | 534/ESA 7432 (WNY | 433-4508) | E-O GSE; Thermal Imaging Systems |
| Smith, H. F. | 53441B | 692-3096 | E-O GSE; SIDEWINDER/CONDOR |
| Skillen, R. L. (CDR) | 5391 | 433-3452 | Photo R&D |
| Tanger, Carl E. | 41111A | 756-1465 | IR Crew Maintenance |
| Tarulis, Vytas A. | 360E | 692-2510 | CCG; Missiles |
| Thyberg, Robert C. | 370 | 692-2511 | CCG Weapon; Fire Control |
| Vranicar, R. | 370E | 692-1741 | E-O ASW Technology |
| Wallace, W. T. | 5333C2 | 692-1741 | Avionics/Surveillance Systems |
| Whiting, Webster K. | 533365C | 692-0818 | Avionics; EW |
| Willis, J. W. | 310B | 692-7414 | E-O Research |

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(202) 692-XXXX - AV 222-XXXX (202) 436-XXXX - AV 296-XXXX

| ` | | | |
|-----------------------|----------------|----------|--|
| Name | Code | Phone | Specialty |
| Alexion, W. C. | 5402 | 692-8921 | Material Acquisition Director - E-O Surveillance (USMC) |
| Anderson, CAPT V. F. | PME124 | 692-1120 | Undersea Surveillance Project Division |
| Bailey, Donald C. | 03A | 692-6411 | E-O R&T |
| Bajus, CAPT J. C. | 03 | 692-6410 | R&T Directorate - Deputy Commander |
| Bucholz, LCDR Roger | PME106 | 692-3793 | HEL |
| Carlson, CDR W. G. | PME107- 23 | 692-0084 | REWSON - AIR IRCM |
| Cronin, G. | PME107- 514 | 692-2350 | IR Simulators; ENEWS |
| Ein, R. | PME107T | 692-0080 | REWSON - E-O Training |
| Fratila, R. | 310A | 692-6096 | R&T Directorate - Information Systems Director |
| Ferreira, David M. | PME107- 521 | 436-0080 | REWSON - IRST |
| Fowler, RADM E. G. | 00 | 692-8480 | Material Acquisition Direc- torate - Deputy Commander |
| Gallotta, CAPT A. | PME107 | 692-2524 | REWSON Project Manager |
| Heidler, C. L. | PME107- 143 | 692-3740 | REWSON - E-O Submarines |
| Himbarger, LCDR R. L. | 320 | 692-6416 | Data Processing for Undersea Surveillance |
| Hollister, CDR F. H. | 310 | 692-6094 | R&T Directorate - Deputy Commander |
| Horowitz, Norman | 51014 | 692-8486 | E-O Engineering Development and Production, EOTAG (Alt) |
| Hullander, CDR C. | PME107- 3 | 692-2484 | REWSON - Director Design to Price |
| | | | |

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|-----------------------|----------------|-------------------------|--|
| Name | Code | <u>Phone</u> | Specialty |
| Jones, Willie H. | 05611 | 692-8486 | Material Acquisition Directorate ~ E-O Engineering Development and Production |
| Kain, Joseph | 350 | 692-6415 | EOCM/OWWG |
| Kauffman, COL T. M. | 540 | 692-8880 692-8928 | Material Acquisition Directorate - USMC and Amphibious Director |
| Koenig, J. A. | 350A | 692-6415 | EOCM |
| Kropf, C. W. | PME107- 4 | 692-2540 | REWSON - Director Intelligence Systems Division |
| Leavitt, CDR R. H. | PME107- 1 | 692-2531 | REWSON - Director Submarines, Reconnaissance, Special Optics, Special Operations |
| Lewis, M. G. | 320 | 692-6416 | R&T Directorate - F.O. Cables |
| Mathews, CAPT D. R. | PME107- 2 | 692-2540 | REWSON - Director AIR REWSON |
| Mead, M. C. | PME124- 20T | 692-8776 | Data Processing Displays - F.D. Cables |
| Miller, G. | 320A | 692-6414 | R&T Directorate - Undersea Surveillance Director |
| O'Brien, J. | PME107- 2 | 692-2484 | REWSON - Design-to-Price IRSS |
| Panella, B. J. | PME107- 2A | 692-2388 | REWSON - Deputy Director AIR REWSON |
| Parker, Mcivor L. Jr. | 310 | 692-6094 | E-O Communications |
| Pellock, CAPT L. | PME107- 523 | 692-3744 | REWSON - Assistant Director Shipboard EOW Systems |
| Powell, Leo T. | 5303 | 692-8461 | TV Systems Design and Procurement |
| Price, Robert C. | PME107- 522 | 692-0080 | REWSON - Reconnaissance/ Intelligence/Special Optics/ Imaging |
| Ricketts, John C. | 310 | 692-6094 | E-O Surveillance (USMC) |
| | | | |

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|------------------------|--|----------|--|--|
| Name | Code | Phone | Specialty | |
| Rigdon, Carl A. | 30422 | 692-6090 | R&T Directorate - E-0 Technology Display/Training Device, EOTAG (Alt) | |
| Ritter, Albert D. | PME107- 52 | 692-0080 | REWSON - Head EO/IR, Systems Branch (Air, Submarine, Surface) | |
| Robinson, O. C. Jr. | 5101 | 692-8486 | Material Acquistion Direc- torate - E-O Engineering Development and Production | |
| Smith, RADM G. | PME107 | 692-2524 | Vice Commander Naval Elec- tronics; E-O Council | |
| Stender, Walter M. | 50424 | 692-8921 | Material Acquisition Directorate - E-O Surveillance (USMC) | |
| Sumney, Larry W. | 3042 | 692-8741 | Head, Solid State/Special Device Technology | |
| Van Sickle, CAPT J. R. | 510 | 692-8481 | Material Acquisition Directorate - Telecommunications Director | |
| Wall, A. J. | PME107- 523 | 692-0080 | REWSON - Multi-Spectral Sensors, Warning Devices, EOCM, Fiber Optics, IRCM | |
| Withrow, CAPT J. | PME107- 5 | 692-3744 | REWSON - Director Shipboard EOW Systems | |
| Youngblood, Dr. W. A. | PME107A | 692-2525 | Deputy REWSON Project Manager | |

NAVSEA

NAVAL SEA SYSTEMS COMMAND WASHINGTON, D.C. 20362

(202) 692-xxxx AV 222-xxxx

| NAME | CODE | PHONE | SPECIALTY |
|---------------------|-------------|-------|---|
| Apted, George (CDR) | 65313 | 1834 | MK-68 E-0 |
| Austin, E. C. | 65312E | 1838 | Guns/Launchers |
| Bachkosky, J. M. | PMS-405B | 5692 | HEL/DPM |
| Curry, E. E. | PMS-404 | 7293 | Radar |
| Eisenberger, E. | PMS-405-423 | 5825 | HEL; T&E Safety Engineer |
| Halligan, Frank J. | PMS-395A-44 | 3921 | Optics; Submarines |
| Jasperse, R. | PMS-404 | 7293 | Acquisition Systems |
| Luning, Alfred O. | PMS-303 | 6407 | Weapons/Fire Control Systems |
| Marcus, Stanley R. | 03в | 9539 | Deputy Commander for Research; Technology Directorate & Technical Director; E-O Council Representative |
| Noonan, B. (Dr.) | PMS-40525 | 8642 | HEL; Fuels |
| Organ, J. W. (CAPT) | 034 | 9765 | Electromagnetic & Acoustic Division; E-O Council |
| Owen, D. M. | PMS-4046 | 2111 | NATO SEA SPARROW |
| Prikals, Peteris | PMS-404 | 7242 | ASMD |
| Riscili, George A. | 6543 | 0666 | Guided Missile Launcher System |
| Ryan, F. N. | 653G | 1161 | MK 92 |
| Rule, F. G. | 6532 | 1850 | Gun Fire Control (Assistant Director) |
| Sandt, C. | PMS-4045 | 7295 | ASMD Missile Systems |
| Sharn, C. F. (Dr.) | 0313 | 9767 | E-O R&T |
| Skolnick, A. (CAPT) | PMS-405 | 5691 | HEL Project Manager |
| Smith, R. L. | 654 | 3852 | E-O Development Coordinator |
| Steed, Willie L. | 100 | 1576 | STILO |
| | | | |

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(202) 692-xxxx AV 222-xxxx

| NAME | CODE | \underline{PHONE} | SPECIALTY |
|-----------------|-----------|---------------------|-----------|
| Stoesell, A. L. | PMS-40530 | 5626 | HEL/APM |
| Tasaka, Toshio | 03415 | 9761 | E-O R&T |

NCSL

NAVAL COASTAL SYSTEMS LABORATORY PANAMA CITY, FLORIDA 32401

(904) 234-4481 AV 436-4481

| NAME | <u>CODE</u> | PHONE | SPECIALTY |
|--------------------|-------------|-------|-----------------------------------|
| Larrimore, Herbert | 731 | 4481 | Optics, Lasers, Photometry, EOTAG |

NESTED

NAVAL ELECTRONICS SYSTEMS TEST AND EVALUATION DETACHMENT PATUXENT RIVER, MARYLAND 20670

(301) 863-3512 + Ext. AV 356-3512 + Ext.

| NAME | CODE | PHONE | SPECIALTY |
|--------------------|------|---------|---------------------------|
| Abell, Edwin L. | 023 | 241/242 | Electronic Visual Systems |
| Ocker, Edward H. | 023 | 241/242 | Electronic Visual Systems |
| Ranta, Marvin J. | 023 | 241/242 | Electronic Visual Systems |
| Roberts, Philip V. | 023 | 241/242 | Electronic Visual Systems |
| Yohman, Daniel J. | 023 | 241/242 | Electronic Visual Systems |

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NAVAL INTELLIGENCE COMMAND HOFFMAN BUILDING ALEXANDRIA, VIRGINIA 22331

(202) 69-XXXXX AV 22-XXXXX

| NAME | CODE | PHONE | SPECIALTY |
|----------------|------|-------|----------------------|
| Dunsmore, Alan | 01 | 72070 | EOTAG Representative |

NAVAL INTELLIGENCE SUPPORT CENTER WASHINGTON, D.C. 20390

(202) 325-xxxx AV 221-xxxx

| NAME | CODE | PHONE | <u>SPECIALTY</u> |
|--------------------------|------|----------|----------------------------------|
| Cobleigh, Arthur G., Jr. | 5343 | 9447 | E-O Intelligence; EOTAG |
| Field, Clarence E., Jr. | 53 | 9540 | Head, Electronics Division |
| Nelson, Robert F., Jr. | 70 | 9447 | Head, Electro-Optics Branch |
| Reeves, Charles | 70 | 763-2141 | E-0 Intelligence |
| Ortmann, Dean A. (CAPT) | 50 | 9100 | Head, Electromagnetic Systems |

NMRDC

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND NATIONAL NAVAL MEDICAL CENTER BETHESDA, MARYLAND 20014

(301) 295-xxxx AV 295-xxxx

| <u>NAME</u> | CODE | PHONE | SPECIALTY |
|------------------|------|-------|--------------------|
| Postow, E. (Dr.) | 43 | 1140 | Biological Effects |

NORDA

NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY NSTL STATION, MISSISSIPPI 39529

(601) 688-xxxx AV 485-xxxx

| NAME | CODE | PHONE | SPECIALTY |
|-----------------|------|-------|--|
| Bright, D. | 302 | 4720 | Water Penetration by Lasers |
| Ferer, K. | 351 | 4712 | Fiber Optics |
| Guagliardo, J. | 335 | 4864 | Laser Remote Sensing (Atmospheric & Subsurface) Non-Linear Optics; Laser Spectroscopy |
| Holland, R. | 351 | 4743 | Fiber Optics |
| Holyer, R. | 335 | 4864 | Satellite Remote Sensing and Image Enhancement |
| Ketchum, D. | 332 | 4810 | E-O Measurement of Sea Ice |
| La Violette, P. | 331 | 4864 | E-O Oceanographic Applications |
| Pressman, A. | 335 | 4864 | Satellite Analysis; Environmental/Intelligence |
| Ruffin, B. | 302 | 4608 | Optical Character Recognition |
| Tooma, S. | 332 | 4810 | E-O Measurement of Sea Ice |

NOSC

NAVAL OCEAN SYSTEMS CENTER SAN DIEGO, CALIFORNIA 92152

| NAME | CODE | PHONE | SPECIALTY |
|-----------------|------|-------|---|
| Albares, D.J. | 811 | 6641 | Integrated Optical Circuits and Fiber Optics |
| Alley, W.T. | 9253 | 6877 | LSG Photo Instrumentation |
| Allgaier, G.R. | 8242 | 7777 | E-O Sub-to-Air Optical Communications |
| Altman, D.E. | 811 | 6641 | Power Supplies for Metal Vapor Sources |
| Anderson, R.D. | 811 | 7975 | Underwater Technology & Systems |
| Arrington, D.C. | 9221 | 6591 | IR Detector Measurements |
| Baechtold, R.D. | 8246 | 6477 | Display Systems |
| Bocker, R.P. | 811 | 6641 | Optical Signal Processing, Coherent/Incoherent |
| Borough, C.K. | 7313 | 7720 | Obstacle Avoidance Systems |
| Bromley, K. | 811 | 6641 | Optical Signal Processing, Coherent/Incoherent |
| Brown, F.R. | 811 | 6641 | Electronic Circuitry for Integrated Optical Circuits |
| Bryant, J.F. | 8341 | 2717 | Fiber Optics, Radiation Effects |
| Cassaboom, J.A. | 8343 | 7494 | Integrated Optical Circuits |
| Caspers, H.H. | 9225 | 6951 | Lum Material |
| Catano, P.S. | 7313 | 7200 | Digital Processing for Optical Systems |
| Celto, J.E. | 811 | 7975 | Pulse Laser, Coding, Power Supplies |
| Chandler, G.F. | 8247 | 6762 | Display Systems |
| Chagnon, A.E. | 8143 | 7351 | Program Manager |
| Clawson, A.R. | 9222 | 6591 | IR Materials |
| Dahike, W.J. | 8246 | 7055 | Display · Devices |
| Davenport, E.W. | 8231 | 7372 | Visual Display |

| NAME | CODE | PHONE | SPECIALTY |
|-----------------|------|-------|--|
| Davies, K.E. | 811 | 7975 | Electronic/Mechanical Servos and Controls |
| Davis, N.M. | 9223 | 6591 | Optical Sensors |
| Dejka, W.J. | 9102 | 2493 | Digital Systems |
| Dillard, G.M. | 8242 | 6258 | POISSON Processed Detection |
| Dosher, G.H. | 734 | 7372 | Visual Display |
| Eastley, R.A. | 811 | 6641 | Fiber Optic Underwater Cables, IR Signatures |
| Eddington, D.C. | 8221 | 6774 | Signal Processing, Digital Systems, Computer Networks |
| Eisenman, W.L. | 9221 | 6591 | IR Detector Measurements |
| Ferrer, J.N. | 7313 | 7720 | Optical Coatings |
| Fletcher, P.C. | 015 | 7036 | E-O Technology, Lasers |
| Floren, E.E. | 7313 | 7200 | Obstacle Avoidance Systems |
| Gabriel, C.J. | 9225 | 6591 | IR Materials |
| Garrett, R.A. | 8233 | 6542 | Bio-Medical Applications |
| Geller, M. | 811 | 7975 | Metal Vapor Sources |
| Gomez, A.D. | 8246 | 6650 | Display Devices |
| Hale, K.F. | 8246 | 7547 | Display Systems/Devices |
| Harris, L.G. | 8235 | 6476 | Display Devices |
| Holma, G.M. | 9242 | 7295 | Optical Digital Circuit Design |
| Howarth, R.F. | 811 | 6641 | Underwater Systems Design |
| Hyde, M.E. | 811 | 6641 | Optical Design |
| Johnston, R.E. | 9231 | 2752 | CCD Measurement |
| Kataoka, R.W. | 8233 | 6542 | Medical Applications |
| Katzman, M. | 8212 | 6100 | Surveillance/Reconnaissance |
| Kiendra, R.M. | 8234 | 6541 | Display Systems/Devices |
| Kochanski, R.J. | 8341 | 7570 | Fiber Optic Systems |
| Krautwald, R.A. | 811 | 7975 | Packaging |

| (714) AV | 225-XXXX 933-XXXX | |
|-------------|--|--|
| CODE | PHONE | SPECIALTY |
| 9251 | 6877 | CCD Measurements |
| 8246 | 7535 | Display Systems, Devices |
| 7313 | 7200 | TV Display Technology |
| 8232 | 7372 | Visual Display |
| 9224 | 6591 | IR Detectors |
| 811 | 6641 | E-O Tracker, CCD Camera |
| 8342 | 7494 | Fiber Optics, Data Transmission |
| 8235 | 6284 | Display Devices, Liquid Crystal |
| 9221 | 6591 | IR Detector Measurements |
| 732 | 2773 | Imaging |
| 8342 | 7570 | Fiber Optic Systems |
| 811 | 7942 | CCD Technology |
| 9222 | 6591 | Instrumentation |
| 9221 | 6591 | IR Detector |
| 9224 | 6591 | Device Physics |
| 7313 | 7264 | Fiber Optics Sub-Systems |
| 9225 | 6591 | IR Lasers |
| 3100 | 7333 | Display Systems, Devices |
| 811 | 6641 | Optical Signal Processing, Coherent/Incoherent |
| 811 | 7975 | Optical Communications, Signal Processing |
| 8245 | 7545 | Display Devices, Liquid Crystals |
| 7313 | 7200 | E-0 Surveillance |
| 7313 | 7944 | E-O Tracker, Pyroelectric Sensors |
| 17 | 7326 | Surveillance Threat Analysis |
| | AV CODE 9251 8246 7313 8232 9224 811 8342 8235 9221 732 8342 811 9222 9221 9224 7313 9225 3100 811 811 8245 7313 7313 | CODE PHONE 9251 6877 8246 7535 7313 7200 8232 7372 9224 6591 811 6641 8342 7494 8235 6284 9221 6591 732 2773 8342 7570 811 7942 9222 6591 9221 6591 9224 6591 7313 7264 9225 6591 3100 7333 811 7975 8245 7545 7313 7200 7313 7944 |

| NAME | CODE | PHONE | SPECIALTY |
|--------------------|------|-------|---|
| Pappert, R.A. | 5324 | 7677 | Specialist in Waveguide Propagation |
| Pavlopoulos, T.G. | 811 | 6641 | Circuits/Integrated Optical Circuits |
| Powers, K.J. | 631 | 6871 | OPs Analysis for Surface Surveillan c e |
| Putnam, W.H. | 811 | 6641 | IR Signatures, Fiber Optics |
| Rast, H.E. | 811 | 7975 | Lum Materials, Fiber Optic Testing |
| Richards, W.E. | 811 | 7831 | E-O Technology & Systems, EOTAG |
| Reed, R.C. | 8342 | 6823 | E-O Systems Test Equipment |
| Robinson, W.R. | 8235 | 7047 | Display Devices |
| Rhode, J.B. | 8344 | 6148 | E-O Systems Test Equipment |
| Ruth, L.A. | 811 | 7975 | Underwater Technology Packaging |
| Sabeh, R. | 8234 | 7372 | Visual Display |
| Schade, W.J. | 7313 | 7740 | IR Lasers, Countermeasures |
| Schimitschek, E.J. | 811 | 7975 | Liquid Lasers, Blue-Green Technology |
| Schumacher, E.R. | 811 | 6641 | Optical Fabrication |
| Silva, J. | 823 | 7531 | Bio-Medical Application |
| Soltan, P. | 811 | 6641 | Display Technology |
| Stang, R.T. | 8124 | 7351 | Fiber Optics |
| Stephens, D.H. | 811 | 7050 | Obstacle Avoidance Systems |
| Stevens, I. | 8233 | 6542 | Bio-Medical Applications |
| Stierwalt, D.L. | 9221 | 6591 | IR Materials |
| Stotts, L.B. | 811 | 6641 | Holographic Storage, Integrated Optical Circuits |
| Symanski, J.J. | 811 | 6515 | Fiber Optics |
| Taylor, H.F. | 811 | 6641 | Fiber Optics, Integrated Optical Circuits |

NOSC

| NAME | CODE | PHONE | SPECIALTY |
|------------------|------|-------|--|
| Taylor, M.J. | 811 | 6641 | Integrated Optical Circuits, Fiber Optics |
| Trias, J.A. | 811 | 7975 | Dye Lasers |
| Walker, R.L. | 7322 | 7566 | E-O Intelligence Systems |
| Wieder, H.H. | 922 | 6591 | LED Materials |
| Weinrich, W.C. | 7313 | 7200 | FLIR |
| White, C.T. | 8223 | 6677 | Vision, Bio-Medical Applications |
| Whitman, W.H. | 7313 | 7200 | LLLTV, FLIR |
| Wildermuth, J.H. | 8341 | 7570 | Integrated Optical Circuits |
| Zaeschmar, G. | 9225 | 6591 | LED Measurements |
| Zeisse, C.R. | 9224 | 6591 | Device Physics |

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NAVAL OCEAN SYSTEMS CENTER SAN DIEGO, CALIFORNIA 92132

| NAME | <u>CODE</u> | PHONE | SPECIALTY |
|-----------------------|------------------|-------------------|---|
| Buntzen, Rodney M. | 1603B | 6243 | HEL Systems Analysis, Underwater Optical Ranging |
| Byram, Dr. George W. | 303 | 2391 | Optical Correlators |
| Funk, Dr. Clarence J. | 6514 | 6862 | Theoretic Analysis of Underwater Imaging Systems |
| Gilbert, Gary D. | 6514 | 6862 | Underwater Applications of Lasers, EOTAG |
| Gordon, Dr. Alan | 6 511 | 7685 | Optical Systems Analy- sis & Performance Prediction |
| Hammond, Robert R. | 14 | 6243 | E-O Systems Analysis |
| Heckman, Paul J. | 6511 | 6686 | Underwater Optical Imaging |
| **Holzschuh, Jack E. | 6531 | (808) 254-4404 | Pressure Tolerant Electronic Devices |
| Means, Dr. Robert W. | 408 | 6607 | Charge-coupled Devices in Optical Processing |
| Ramstedt, Clarence F. | 407 | 7876 | Optical Ocean Surface Effects |
| Redfern, John T. | 408 | 6613 | Fiber Optics and Communications |
| Waltz, Allen R. | 6511 | 6686 | Underwater Lights |
| **Wilkens, George A. | 6533 | (808) 254-4433 | Underwater Cabling, Including Fiber Optic Cables |
| Whitehouse, Harper J. | 408 | 7621 | Visual/IR Image Processing |

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|---------------------------|------|---------------|--|
| Armstead, Robert L. | 61Ar | 2125/ 2806 | Atmosphere Propagation |
| Bank, Milton H. II | 57Bt | 2866 | Aircraft Vulnerability; Structural Response |
| Biblarz, Oscar | 57Zi | 2972 | HEL; Kinetics; Thermal Blooming |
| Cooper, Alfred W. | 61Cr | 2452/ 2806 | Laser-Plasma Production; Atmospheric Propagation |
| Crittenden, Eugene C. Jr. | 61Ct | 2855/ 2806 | Atmospheric Propagation |
| Davidson, Kenneth L. | 51Ds | 2309/ 2516 | Optical Propagation; Atmospheric Turbulence |
| Fairall, C. W. | 61 | 2219/ 2806 | Atmospheric Turbulence |
| Fuhs, Allen E. | 57Fu | 2958 | HEL; Thermal Blooming in Transonic Slewing |
| Houlihan, Thomas | 59Hm | 2586 | Atmospheric Turbulence and Laser Propagation |
| Kalmbach, Sydney H. | 61Kb | 2848/ 2806 | Atmospheric Propagation |
| Milne, Edmund A. | 61Mn | 2886/ 2806 | Atmospheric Propagation |
| Powers, John P. | 52Po | 2679/ 2156 | Laser Communications; Holography; Light-Sound Interactions |
| Rodeback, G. Wayne | 61Rn | 2185/ 2806 | Atmospheric Propagation |
| Schacher, Gordan E. | 61Sq | 2409/ 2806 | Atmospheric Turbulence |

NAVAL RESEARCH LABORATORY WASHINGTON, D. C. 20375

| CODE | PHONE | SPECIALTY |
|--------|--|--|
| 6336 | 3345 | Combustion Effects; Advanced Structural Material ` |
| 1408 | 3726 | Thermal Blooming, Theory Atmospheric Transmission; E-O CM/ CCM Coordinator |
| 6700.1 | 3762 | UV/X-ray Laser Optics - Coherent Optics |
| 5262 | 2534 | Solid State Imaging |
| 6650 | 3222 | Theory Atmospheric Transmission |
| 5260 | 2408 | CCD, Solid State Imaging |
| 7142B | 2015 | LLLTV, E-O Detectors |
| 5554 | 3276/ 3612 | Laser Effects; Harden-ing |
| 6362 | 3310 | Laser Window Materials |
| 6680 | 2154/ 2549 | Diagnosis of Laser In- duced Plasma Emissions |
| 8320 | 2278/ 3317 | Meteorology - Atmos- pheric Optics |
| 5535 | 3674 | Holography, Optics |
| 5570 | 2057 | Short Pulse Lasers, Optics |
| 7142 | 3287 | Solar Physics (Vidi- cons, Photography) |
| 7146B | 3578 | UV Spectroscopy |
| 5564 | 2276 | HEL Subsystems |
| 8133 | 3336 | Absorption Scattering in Glass |
| | 1408 6700.1 5262 6650 5260 7142B 5554 6362 6680 8320 5535 5570 7142 7146B 5564 | 6336 3345 1408 3726 6700.1 3762 5262 2534 6650 3222 5260 2408 7142B 2015 5554 3276/3612 6362 3310 6680 2154/2549 8320 2278/3317 5535 3674 5570 2057 7142 3287 7146B 3578 5564 2276 |

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|-------------------------|--------|---------------|--|
| Burns, Dr. William K. | 5507 | 3298 | Integrated Optics |
| Carruthers, Dr. George | 7123 | 2764 | Imaging Devices;*Elec- tronographic Cameras |
| Carter, Dr. William H. | 5531C | 3408 | E-M Field Theory and Coherance |
| Champagne, L. | 5540 | 2813 | Electric Discharge Lasers |
| Chaskelis, H. H. | 8431 | 3613 | Underwater Schleiren Photography |
| Chubb, Dr. T. A. | 7120.0 | 3580 | Solar Physics (TV, Imaging Devices) |
| Curcio, Joseph A. | 5560 | 3006 | Field Radiometry; Atmospheric Optics |
| Daspit, Frank A. | 5536 | 2276 | E-O Systems; Radi- ometry |
| Davey, Dr. J. E. | 5210 | 2524 | Solid State Imaging |
| Davis, Dr. C. M. | 8130 | 2491 | Opto-Acoustics |
| Denningham, Robert L. | 5552 | 2729 | Optical Warfare, Laser Effects |
| DelGrosso, Dr. V. A. | 8420.1 | 2696 | Modulation Transfer Function in Water |
| DeRosa, J. L. | 6415 | 2319 | Laser System Design |
| Dixon, Robert H. | 5530 | 2826 | Optical Plasma Diag- nostics |
| Djeu, Dr. Nicholas | 5540 | 2255 | Gas Lasers |
| Dowling, Dr. James A. | 5567 | 3007 | Propagation and Spectroscopy |
| Drummeter, Dr. Louis F. | 5501 | 3681/ 2847 | *Optics, *E-O Admini- stration |
| Easton, R. | 5535 | 3674 | Photography, Holo- graphy |
| Eckardt, R. C. | 5554 | 3535 | Fast Pulse Laser Systems |

| NAME | CODE | <u>PHONE</u> | <u>SPECIALTY</u> |
|-------------------------|--------|--------------|---|
| Elliot, J. D. | 8310 | 2176 | IR Radiation from Ocean; Acting |
| Esterowitz, Dr. Leon | 5554 | 3237 | Laser Effects, EOCM |
| Elton, Dr. R. C. | 5504EL | 2754 | *X-ray Lasers, Laser Interactions |
| Faust, Dr. Walter L. | 5504.4 | 2499 | Laser Spectroscopy; Short Pulse Lasers |
| Fluhr, Fredrick R. | 5508 | 2955 | Optical Engineering; Gas Dynamic Lasers |
| Fox, Dr. R. B. | 6120 | 2130 | Laser Hardening |
| Friedman, Daniel | 5553 | 3689 | EOCM/Systems; IR Seekers |
| Gandy, Dr. Harold W. | 7905 | 72830 | E-O Systems, Laser Physics Program Status |
| Giallorenzi, Dr. Thomas | 5514 | 3209 | *Integrated Optics; *Non-Linear Optics |
| Giuliani, John F. | 5540 | 2255 | Laser Effects |
| Goldberg, Dr. Lawrence | 5570 | 3009 | Non-Linear Optics, Tunable Laser |
| Goodell, Dr. William | 5553 | 2115 | EOCM, E-O Systems |
| Grieg, Dr. J. R. | 6763 | 2705 | Spectroscopic Diagnos- tics |
| Haas, Dr. M. | 5232 | 2260 | Laser Window Materials |
| Hall, George L. | 5508 | 2955 | HEL Subsystems |
| Hanley, Dr. S. T. | 5567 | 3007 | HEL Physics |
| Hansen, Dr. R. J. | 8441 | 2904 | Laser Velocimeters |
| Harvey, Dr. A. B. | 6110 | 3340 | Chemical Lasers, Molecular Spectroscopy |
| Harvey, George L. | 1409 | 3272/3 | EOTPO/Foreign Techno- logy; IR Propagation |
| Heemstra, F. W. | 8405 | 72463 | Optical Instrumentation |

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|---------|---------------|--|
| Hettche, Dr. L. R. | 6300 | 2926 | Pulse Laser Effects |
| Hicks, G. T. | 7120.4 | 2506 | LLLTV |
| Holmes, J. C. | 7127.1 | 2513 | Sensors, UV Photometry and Imaging |
| Horton, R. | 5567 | 3007 | Optical Propagation |
| Howard, Dr. R. A. | 7141H | 3137 | Solar Physics (Vidi- cons; Photography) |
| Hughes, R. G. | 8132 | 2492 | Flash Lamps (Metal Ion Doping) |
| Jeck, R. | 8323 | 2437/6 | Atmospheric Propaga- tion - Aerosols |
| Johnson, Charles Y. | 7127.01 | 3329 | Sensors, UV Photometry and Imaging |
| Jones, Dr. W. W. | 7750 | 3214 | Spectroscopic Diagnos- tics of UV Lasers |
| Kabler, Dr. M. N. | 5580 | 2223 | *Optical Memories - *Optical Materials |
| Kaplan, Dr. Ray | 5234 | 3414 | Magneto-Optics |
| Kershenstein, Dr. John | 1409 | 3045 | EOTPO, Laser Physics, HEL Mirrors and Windows |
| Kervitsky, J. | 7123.3 | 2764 | Photocathode and Imaging Devices |
| Knestrick, G. Lloyd | 5552 | 3347 | Radiometry; Laser Effects |
| Kohler, C. R. | 5742.3 | 5936 | RF/IRCM |
| Koomen, M. J. | 7141 | 3529 | Solar Physics (Vidi- cons, Photography) |
| Kreplin, R. W. | 7125.0 | 2603/ 3180 | X-ray UV Detectors |
| Kruer, Melvin R. | 5554 | 3276 | Laser Effects |
| Lee, Dr. Tong Nyong | 5530 | 3299 | Laser Produced Plasma; X-ray Instrumentation |

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|--------|---------------|--|
| Lessoff, H. | 5220 | 3096 | Laser Window Materials |
| Lin, Dr. M. C. | 6110 | 3686 | Chemical Lasers |
| Loughmiller, C. M. | 5309 | 2228 | Computer Simulation |
| MacCallum, Dr. John M. | 1409 | 3045 | EOTPO, E-O Systems, E-O Administration |
| May, Dr. Thomas H. | 5531M | 3281 | E-0 Systems Analysis |
| McDonald, Dr, J. R. | 6110 | 73686 | Dye Lasers |
| McLean, E. A. | 6731 | 2728/30 | E-O Photography, Inter- ferometry |
| McMahon, John M. | 5520 | 2730 | Solid and Gas Laser Design |
| McNutt, Dr. Douglas P. | 7122.0 | 2749 | IR Astronomy; Radiometry |
| Mellman, Stephen | 7044 | 2635 | Optical Communications |
| Meredith, E. A. | 5751 | 3495 | RF/IRCM |
| Milton, Dr. A. Fenner | 5504MI | 3237 | E-O Systems, Fiber Optics, Integrated Optics |
| Moore, Dr. W. J. | 5275 | 3261/ 2594 | IR Detectors |
| Moroz, S. A. | 5753 | 3495 | RF/IRCM, IR Seekers |
| Nagel, D. | 6682 | 2154/ 2549 | Diagnosis of Laser In- duced Plasma Emissions |
| Nash, G. E. | 6490 | 2741 | Theoretical Modeling of Thermal Response |
| Neubauer, Dr. W. | 8132 | 2283 | Schleiren Photography- Acoustic Waves |
| Ngai, Dr. K. L. | 5277 | 2594 | Electron-Phonon Inter- action |
| Nicolas, K. R. | 7142N | 2517 | Solar UV Spectroscopy |
| Opal, C. B. | 7123.1 | 2764 | LLLTV, Imaging Devices |
| Pablo, Manuel R. | 1409 | 3799 | EOTPO, E-O Systems and Analysis, E-O Data Base |

| NAME | CODE | PHONE | SPECIALTY |
|--------------------------|--------|---------|--|
| Palik, Dr. Edward D. | 5230 | 3896 | Surface Optical Effects |
| Palumbo, Dr. Louis J. | 5540 | 2028 | Laser Interactions/ Analysis |
| Patterson, R. B. | 8422 | 2171 | Optical Instrumentation |
| Patten, Dr. Raymond A. | 5530 | 3049 | Optical Intelligence, Applied Optics, OIWG |
| Pechacek, Dr. R. A. | 6763 | 2077 | Plasma Heating by Laser Radiation |
| Rabin, Dr. H. | 7000 | 2964 | NRL Administration, Non-Linear Optics |
| Reintjes, Dr. J. | 5520 | 3299 | Fast Pulse Laser Systems |
| Rice, R. W. | 6360 | 3548 | IR Domes, Laser Windows/ Effects |
| Ripin, B. H. | 6732 | 2730 | Laser Produced Plasma |
| Rosenstock, Dr. H. B. | 6404 | 2225 | Optical Materials, Multi-Phonon Processes |
| Royt, Dr. Terry R. | 5570 | 2057 | Ultra-Short Pulse Tunable Laser Systems |
| Ruskin, R. E. | 8320 | 2436 | UV Humidity Measurements |
| Sanford, Dr. R. J. | 8431 | 3384 | Holography-Stress Anal- ysis, Photoelasticity |
| Schindler, Dr. Albert | 6000 | 3566 | *Material Effects - Optical Radiation; NRL Administration |
| Schriempf, Dr. J. Thomas | 6330 | 2602 | Material Effects, (Pulse Laser Effects), Optical Radiation |
| Schwartz, Dr. J. W. | 7005 | 2051 | Optical Communications |
| Searles, Dr. Stuart K. | 5540 | 2255 | Gas Lasers |
| Sheridan, Dr. James P. | 5570 | 3100/06 | Liquid Crystals |
| Shivanandan, K. | 7122.1 | 2749 | Helium Cooled Detectors |
| Sigel, Dr. G. H. | 5584 | 2870 | Fiber Optics |

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|---------------------------|--------|-------|---|
| Stamm, Gordon L. | 5534 | 2193 | Field Radiometry |
| Stamper, Dr. J. A. | 6730 | 2683 | Laser-Produced Plasma |
| Stegman, Richard L. | 6333 | 2924 | CW/Pulsed Laser Thermal Responses |
| Steinberg, Dr. Richard A. | 4109 | 3045 | EOTPO, E-O Systems Performance Modeling |
| Stilwell, Denzil | 7914 | 3355 | Optical Information Processing |
| Sullivan, A. M. | 6384 | 2349 | Stressed Metalic Skin Studies |
| Szuszcswicz, Dr. E. P. | 7127.0 | 2513 | Sensors, UV Photometry/ Imaging |
| Takken, Dr. Edward H. | 5550 | 3237 | Optical Propagation, E-O Systems |
| Tartanian, C. N. | 7918C | 2715 | Active/Passive Stabi- lized TV Systems |
| Teitler, Dr. S. | 1405 | 2445 | Multi-Layer Optics |
| Tilford, S. G. | 7146 | 2737 | High Resolution UV Spectroscopy |
| Ulrich, Dr. Peter B. | 5560 | 3068 | Theory-Atmospheric Propagation |
| Van Hoosier, M. E. | 7142V | 3287 | Electrophotography |
| Wagner, Dr. R. J. | 5275 | 2594 | Far IR Lasers |
| Walsh, Dr. John L. | 1409W | 3037 | EOTPO, E-O Technology and Systems Analysis |
| Watt, Dr. Williams S. | 5540 | 3217 | Gas Lasers - Chemical Lasers |

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| NAME | CODE | PHONE | SPECIALTY |
| Waynant, Dr. Ronald W. | 5540 | 2683 | UV/X-ray Lasers |
| Weinberg, Dr. Donald L. | 5552 | 3118 | Laser CM/Effects |
| Weller, Dr. C. S. | 7124 | 2481 | UV Spectrometric/ Imaging Devices |
| Weller, Dr. Joseph F. | 5570 | 3298 | Integrated Optics |
| Wenzel, Dr. Richard F. | 6415 | 2935 | Laser Damage |
| West, Edward J. | 5570 | 2122 | Integrated Optics |
| Wexler, Dr. B. | 5540 | 2813 | Laser Physics |
| Whitney, Wayne T. | 5540 | 2813 | Electrical Discharge Lasers |
| Widing, Dr. K. G. | 7144 | 2605 | Solar UV Spectroscopy |
| Wieting, Dr. T. J. | 6412 | 2101 | Optical Properties of Materials |
| Williams, K. G. | 8301 | 2530 | Visible Spectrum of Kelvin Waves |
| Wyman, Paul W. | 5531W | 3281 | E-O Systems Analysis |
| Young, Dr. F. | 5203 | 2807 | Diagnosis of Laser In- duced Plasma Emissions |
| Young, J. M. | 7124.3 | 2513 | Sensors-UV Spectroscopy/ Imaging |

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| <u>NAME</u> | <u>CODE</u> | PHONE | <u>SPECIALTY</u> |
|------------------|-------------|-------|------------------------|
| Church, James W. | 6114M1 | 0304 | FLIR; LLLTV |
| Siahatgar, S. | 6174F | 3723 | HEL; Laser Radar; IRCM |

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(301) 267-XXXX AV 281-XXXX

| NAME | CODE | PHONE | SPECIALTY |
|-----------------------|------|----------|--|
| Baker, Francis E. | 2732 | 267-2363 | LADAR, ASW Applications |
| Burns, Robert H. | 2833 | 267-3527 | IRCM, IR Suppression Designs |
| Dhir, Dr. S. K. | 1844 | 227-1426 | Holography |
| Dickey, Joseph W. | 2732 | 267-2768 | Holography, Inter- ferometry, E-O Coordi- nator, EOTAG |
| Friedman, Dr. Seymour | 2823 | 267-2835 | Holography |
| Gann, Jerry D. | 2833 | 267-2352 | Ship IR Detection, Ship IR Signature Measurements |
| Greenberg, Melvin | 2833 | 267-2461 | IRCM, LCM, Spectro- scopy, Optical Proper- ties of Surface Materials |
| Griswold, Lyman W. | 2732 | 267-2763 | Laser Velocimeters, Interferometry Range Finders, Underwater Applications |
| Hall, Jay | 2773 | 267-3123 | Dye Lasers |
| Kline, Ruth E. | 2833 | 267-2352 | IR Signatures, IR Pro- perties of Materials |
| Laster, Donald R. | 2732 | 267–2763 | Laser Velocimeters, Water Turbulence Measurements |
| Pearcy, Olin M. | 2833 | 267-2352 | IR Atmospheric Attenu- ation |

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| NAME | CODE | PHONE | <u>SPECIALTY</u> |
|------------------------|------|----------|--|
| Peterson, Dr. Frank B. | 1552 | 227-1325 | Holography |
| Pendergast, Patrick O. | 2742 | 267-2964 | Fourier Optics |
| Sikora, Jerome P. | 1731 | 227-1787 | Holography |
| Smith, Stephen G. | 2773 | 267-3123 | Tunable Dye Lasers |
| Tate, Ronald C. | 2732 | 267-2665 | Interferometry, Water Turbulence Instrumen- tation |
| Urbach, Dr. H. B. | 2720 | 267-2348 | Fusion, Isotope Separation |
| Waltman, Donald J. | 2732 | 267-2869 | Laser Velocimeters, Water Turbulence Measurements |
| Weber, Robert A. II | 2821 | 267-2160 | Welding |
| Webster, W. A. III | 2773 | 267-3123 | Tunable Dye Lasers |
| Whitesel, Henry K. | 2732 | 267-2163 | Doppler Laser Veloci- meter, Range Finders |
| Wooden, Bruce | 1105 | 227-1852 | HEL |

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|--------------------|-------|-------|--|
| Arthur, R.J. | G-40 | 8002 | Head, Guided Projectile Div. |
| Ely, R.I. | DF-16 | 8026 | CCD Technology |
| Ferris, K.D. | DF-14 | 8661 | CCD Technology |
| Fontenot, L.J. | N-54 | 7101 | Head, E-O Systems Branch, SEAFIRE Program Manager |
| Grzegozewski, R. | N-54 | 7281 | E-O Systems Analyst |
| Hepfer, K.C. (Dr.) | N-54 | 7101 | E-O Systems Analyst, EOTAG |
| Holden, R.A. | F-14 | 7497 | Laser Technology |
| Horman, S.R. | N-54 | 7332 | Advanced Warning Techniques |
| Hoye, W.E. | N-54 | 7333 | Laser Ordnance Designators |
| Lerner, E.M. | N-54 | 7101 | SEAFIRE |
| McDowell, V.P. | N-54 | 7104 | E-O CM/CCM |
| Overman, J.M. | N-54 | 7283 | MK 68 EOSS |
| Schmidt, R.L. | N-50 | 7101 | Head, Weapons Control Div. |
| Shipp, J.B., III | N-56 | 743Î | MK 68 EOSS |
| Simpson, H.L., Jr. | N-54 | 7101 | SWCM Missile Patrol Boat E-O Director |
| Spicer, W.E. | N-54 | 7509 | Laser Ordnance Designators |
| Taczak, W.J. | N-54 | 7332 | Advanced Warning Technique |
| Tokar, J.M. | N-54 | 7509 | SEAFIRE |
| Troyer, D.E. | N-54 | 7331 | HEL Technology |
| | | | |

NAVAL SURFACE WEAPONS CENTER WHITE OAK LABORATORY SILVER SPRING, MARYLAND 20910

(301) 394-XXXX AV 290-XXXX

| NAME | <u>CODE</u> | PHONE | SPECIALTY |
|-----------------------|-------------|---------|---|
| Adolph, H.G. | WR-11 | 2477 | High Energy Materials Synthesis & Properties |
| Altman, W.P. | CF-46 | 2093 | Laser, Optics |
| Anderson, K. | CA-32 | 2198 | Optical Fuzing |
| Andreotti, J.R. | CR-42 | 2796 | Infrared Countermeasures |
| Bell, C.E. (Dr.) | CR-42 | 1998 | Laser Interaction with Media |
| Beyers, R.R. | CA-11 | 1375 | Missile Systems Vulnerability Analyst |
| Bilow, H.J. (Dr.) | CA-21 | 2352 | HEL, Propagation |
| Bis, R.F. (Dr.) | WR-34 | 1298 | Sensors, IR Detectors |
| Black, G.M. | CR-34 | 2783 | Laser Illuminators |
| Blake, G. | CA-32 | 1394 | Fiber Optic Cabling |
| Brooks, D.A. | CA-22 | 2893 | HEL, Instrumentation |
| Browning, F.G. | CA-33 | 1970 | Optical Fuzing |
| Brundick, H. | CA-23 | 213) 39 | NPT, Operations (HAC) 91-0711 ext 2025 |
| Cawley, R.G. (Dr.) | CR-41 | 2256 | Heritage/IR Program |
| Cook, H.A. | CA-22 | 1232 | AUASAM |
| Culpepper, R.M. (Dr.) | CA-11 | 1375 | HEL Vulnerability Team Leader |
| Dayhoff, E.S. (Dr.) | CR-42 | 2796 | Lasers |
| Demas, N.L. | CA-23 | 1510 | IR Decoy |
| DeMoss, W.A. | CA-22 | 1286 | NPT, Data Analysis |
| Dengel, 0. | CR-22 | 48-4224 | IR Decoys |
| Graham, W.J. | CF-46 | 1692 | Laser Radar/OWWG |
| Griff, N. | CR-42 | 2796 | HEL, Sensors, Damage Effects |
| Hardy, M.G. | CA-11 | 1378 | Aero Effects on Laser Damage |

(301) 394-XXXX AV 290-XXXX

| NAME | CODE | PHONE | SPECIALTY |
|----------------------|-------|---------|--|
| Harris, E.L. (Dr.) | CA-20 | 1699 | Gas Lasers, EOTAG |
| Hewitt, R. | CA-22 | 1693 | Meteorology Instrumentation |
| Hirschman, A. | CR-42 | 2797 | Search & Surveillance Systems Thermal Imaging, Holography |
| Houston, B.B. (Dr.) | CR-34 | 1299 | High Speed Civic Conductors Devices |
| Hudson, D. (Dr.) | CF-46 | 2309 | Lasers |
| Infosino, C.J. (Dr.) | CR-42 | 1974 | Optics/Atmospheric Physics |
| Jensen, R.E. (Dr.) | CF-46 | 2093 | Laser Radar |
| Johnson, R.D. | CA-23 | 213) 53 | HEL, Field Test Manager 5-4321 |
| Katz, B.S. (Dr.) | CR-42 | 2796 | Atmospheric Physics |
| Kessler, B.V. (Dr.) | CR-42 | 1998 | Lasers |
| Kirkpatrick, D. | CA-32 | 2198 | Optical Fuzing |
| King, W.L. | CE-13 | 1533 | Optics, Lasers |
| Klamm, G.E. | CA-33 | 1529 | Optical Fuzing |
| Knutsen, W.N. | CA-22 | 1688 | HEL, Instrumentation |
| Larson, C.W. | CR-42 | 1989 | HEL, Guidance & Target Sensors |
| Lee, Lester (Dr.) | CR-22 | 48-479 | HEL, Instrumentation |
| Maccabee, B.S. (Dr.) | CR-42 | 2779 | Laser Interaction with Media |
| Martin, W.R. | CA-23 | | NPT Contract Liaison |
| Matlack, D.E. | CR-42 | 1989 | Infrared Technology |
| Matra, J.P., Jr. | CA-21 | 1941 | Missile Structures Analysis |
| McKindra, C.D. | CA-11 | 1237 | HEL, Vulnerability, Heat Transfer |
| McLeod, G.A. | CA-22 | 1693 | HEL, Instrumentation |
| Peer, C.F. | CA-23 | 1319 | IR Decoy |
| Petropolous, S.K. | CR-42 | 2407 | Thermal Imaging and Surveillance |

NSWC/WOL

(301) 394-XXXX AV 290-XXXX

| NAME | CODE | PHONE | SPECIALTY |
|-------------------------|-------|----------|--------------------------------|
| Riedl, H.R. | CR-34 | 2774 | Thermal Imaging |
| Scharnhorst, K.P. (Dr.) | CR-34 | 2783 | Thermal Imaging |
| Schoolar, R.B. | CR-34 | 2783 | Thermal Imaging |
| Stimler, M. | WU-21 | 1563 | Lasers, Optics, Opto-Acoustics |
| Templin, H.A. | CR-42 | 1989 | Optics |
| Warner, M.L. | CA-22 | 2893 | HEL, Instrumentation |
| Weston, A.E., III | CA-22 | 1678 | HEL, Instrumentation |
| Wilmot, G. | CR-22 | 748-2552 | IR Spectroscopy |
| Whitman, E.C. (Dr.) | CU-20 | 1715 | Image Processing |

NSWSES

NAVAL SHIP WEAPON SYSTEM ENGINEERING STATION PORT HUENEME, CALIFORNIA 93043

(805) 982-xxxx AV 360-xxxx

| NAME | CODE | PHONE | SPECIALTY |
|----------------|------|-------|---|
| Samojen, T. J. | | 5804 | E-O Weapons (Ships) |
| Shelton, W. L. | 6211 | 5823 | E-O Surveillance and Detection; T&E (Ships) |
| Wilson, S. D. | 6211 | 5823 | E-O Surveillance and Detection; T&E (Ships) |

NTEC

NAVAL TRAINING EQUIPMENT CENTER ORLANDO, FLORIDA 32813

(305) 646-xxxx AV 791-xxxx

| NAME | CODE | PHONE | SPECIALTY |
|-------------------------|------|-------|--|
| Breglia, Denis Robert | 73 | 5464 | Holography; Lasers |
| Chambers, Walter S. | 74 | 4491 | TV Displays |
| Derderian, George | 73 | 4609 | Lasers; Optics and Displays; EOTAG |
| Herndon, John W. | 74 | 4491 | TV Displays |
| Kashork, Edward F. | 74 | 4491 | TV Displays |
| Kulik, John J. | 73 | 4609 | TV Displays |
| Maldonato, Eugene D. | 73 | 5464 | Optics and Displays |
| Marshall, Albert H. | 73 | 5464 | Laser/Sensors Training Devices; Team Leader |
| McKechnie, John C. | 73 | 4609 | TV Displays |
| Mohon, Windell N. | 73 | 5464 | Holography and Lasers |
| Oharek, Frank J. | 73 | 4609 | Optics/Displays; Team Leader |
| Palmer, Robert G. Sr. | 211 | 4483 | Optics/Displays |
| Raffo, Joseph U. | 211 | 4483 | Optics/Displays |
| Rodemann, Alfred H. | 73 | 5464 | Holography and Lasers; Team Leader; EOTAG Alternate |
| Rosendahl, Gottfried R. | 73 | 5464 | Optics and Displays; Team Leader |

NUSC

NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON, CONNECTICUT 06320

(203) 442-0771 + Ext AV 636-XXXX

| NAME | CODE | PHONE | SPECIALTY |
|--------------------|------|-------|---|
| Allard, F.C. | 3431 | 2192 | Fiber Optics, Optical System Design |
| Ball, J.R. | 343 | 2864 | Periscope Optical Test Equipment & Computer Design |
| Fein, M.O. | 3101 | 2645 | Optical Signal Processing |
| Flatley, J.P. | 343 | 2622 | E-O Communication & Stabilization Systems |
| Floyd, C.M. | 3492 | 2627 | Periscope E-O, Laser Detection Systems |
| Free, L.J. | 4343 | 2439 | E-O Shipboard Tests and Analysis, EOTAG (Alt) |
| Green, E. (Dr.) | 313 | 2684 | Optical Signal Processing |
| Green, M. (Dr.) | 313 | 2683 | Laser TV Systems |
| Johnson, C.D. | 4312 | 2219 | Underwater Holography |
| Middleton, A.W. | 343 | 2625 | Optical Communication Systems |
| Motin, G.N. | 343 | 2621 | Periscope E-O Devices, Image Intensification |
| Polley, R.J. | 343 | 2350 | Submarine E-O, Underwater Imaging, EOTAG |
| Randall, R.J. | 343 | 2623 | Submarine Photo-Optics |
| Rasi, R.T. | 343 | 2630 | Optical Communications, Receiver Design |
| Replogle, F.S. | 343 | 2620 | Underwater Imaging, Periscope & Atmospheric MTF Assessment |
| Ruhlmann, H.K. | 343 | 2640 | Periscope E-O Interfacing |
| Shajenko, P. (Dr.) | 313 | 2788 | Holography & Laser Transducers |
| Sheldick, P.S. | 343 | 2158 | Periscope Camera & TV Systems |
| Solarz, P. | 343 | 2454 | Optical Communications |
| Stachnik, W.J. | 343 | 2620 | Underwater Optical Systems/ Ocean Science |

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| NAME | CODE | PHONE | SPECIALTY |
|-------------------------|-------|---------------|------------------------------------|
| Allen, Edward | 32403 | 7413/ 7350 | IR Flares |
| Allen, Edwin M. | 3941 | 3364 | IR Seeker Mech Design |
| Amundson, Paul H. | 0100 | 3551 | FLIR |
| Ankeney, D. P. | 31803 | 3326 | IR/E-O Systems |
| Archibald, Phillip | 3814 | 2869/ 3832 | Optical Testing |
| Arnold, Phillip G. | 394 | 3528 | Systems Development (AGILE) |
| Bailey, Ted | 3924 | 2851 | IRCCM, E-O Technology |
| Barber, Stephen E. | 3630 | 2630 | CO2 Lasers, IR |
| Bell, Ernest M. | 3635 | 3361 | Laser Technology |
| Bennett, Dr. Harold E. | 38101 | 2869/ 3832 | IR Material (Optics) |
| Bennett, Dr. Jean M. | 3818 | 2869 | Interferometer (Optics) |
| Benton, Dr. E. E. | 39401 | 3528 | E-O Coordinator, EOTAG |
| Bergman, Dr. Truman G. | 3151 | 3723 | Laser Detection/Ranging |
| Billings, John C. | 3343 | 3958 | Optical Fuzing |
| Bird, Richard E. | 3311 | 3948 | E-O Fuzes |
| Blackwell, Raymond | 39043 | 2906/ 3290 | E-O Systems |
| Black, Henry | 5515 | 2047 | Integrated Optics |
| Bottka, Dr. Nicholas | 3819 | 2801 | IR Material, E-O Material |
| Bowen, James R. | 362 | 2214 | IR Optics, Seekers, Optical Fuzing |
| Bullock, Dr. Cecil Kent | 3311 | 3949 | CO2 Lasers |
| Bumgardner, Jon | 3944 | | E-O Receiver CKT Design |
| Burdick, Dr. D. L. | 3813 | 2898/ 2970 | IR Detectors |

ERRATA SHEET

1. This Errata Sheet is intended to assist recipients of this E-O Directory in submitting additions, deletions and/or changes to the directory as an aid in publishing future editions. It is requested that all recipients review the directory as it pertains to their activity. Changes should be submitted to:

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For convenience this sheet is already self-addressed on the back.

2. Please include the following additions, deletions,

| and/or changes to futur Professional Directory: | e editions of the EOTPO | |
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| | | - |
| | | - |
| | Signature | - |
| | Command/Activity | |
| | Phone# | - |

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|--------|---------------|--|
| Burge, Dennis K. | 3818 | 2869/ 3832 | Optical Surface Measure- ments |
| Burkey, D. C. | 40405 | 5429 | E-O Trackers (Fire Control) |
| Burroughs, Hubert H. | 3323 | 3030 | E-0 Fuzes |
| Burt, Warren T. | 3106 | 3583 | E-0 Systems |
| Bush, John E. | 3275 | 7220/ 7203 | Gas Laser Device Technology |
| Campbell, Robert W. | 31505 | 3583 | Laser Designators/FLIR PAVE KNIFE |
| Camphausen, Fred H. | 3913 | | E-O Systems Analysis |
| Capps, William L. | 3943 | 2237 | IR Measurements |
| Cartwright, W. F. | 0330 | 2562 | IR Seeker Design |
| Claunch, Minard W. | 3943 | 2237 | IR Measurements |
| Clendennin, W. G. | 390811 | 3475 | IR Search Sets for ASMD |
| Cowan, Douglas W. | 31012 | 3588 | NOGS |
| Crawford, Jack A. | 395 | 2254 | E-O Systems, TV Tracker |
| Crisler, John R. | 3341 | 3788 | Optical Fuzing |
| Cunningham, Robert D. | 3951 | 3611/12 | E-O Systems, WALLEYE |
| Decker, Dr. Donald L. | 3818 | 3247 | IR Materials (Optics) |
| Decker, Paul R. | 3175 | 2596/ 3167 | Display Image Quality Measurements |
| Dettling, Ronald F. | 3275 | 7300 | Gas Laser Device Technology |
| Donovan, Dr. T. M. | 3818 | 2869 | Detectors, Photoemission Amorphous Semiconductors |
| Dupuy, Chester J. | 3321 | 3020 | IRCM |
| Elliot, Shelden D. Jr. | 6022 | 2731/ 2410 | Lasers |
| Erickson, Ronald A. | 3175 | 2591 | Target Acquisition Working Group |

| <u>NAME</u> | CODE | PHONE | SPECIALTY |
|------------------------|-------|---------------|--|
| Essig, Fred C. | 381 | 2970/77 | Detectors, Spectroscopy |
| Estrada, A. E. | 3333 | 2433/24 | Optical Fuzing |
| Fenneman, Dr. D. B. | 3275 | 7220/33 | Gas Laser |
| Finder, William F. | 6224 | 446-3511 | IR Measurement Analysis |
| Fisher, Dr. R. E. | 39 | 2504 | IRSS/IR Seekers |
| Fitzgerald, William C. | 3941 | 3364 | IR Optics |
| Foote, K. R. | 4543 | 7511/21 | IR Flares |
| Forrester, Howard M. | 3341 | 3064 | Optical Fuzing |
| Fountain, Clifford | 3625 | 2047 | IR |
| Freedman, Robert J. | 31408 | 5219 | A7E TRAM/Avionics Inte- gration |
| Freitag, Walter E. | 39012 | 2508/ 2050 | E-O Guidance Systems |
| Fujiwara, Ike | 3157 | 3341 | Laser Technology |
| Gaar, Augustus G. | 3621 | 3597 | IR Engineering |
| Gorrono, B. J. | 3150 | 3583 | EOT/FLIR |
| Goss, Dan A. | 3331 | 2445 | Optical Fuzing |
| Gravelle, Noel D. | 3344 | 3769 | Optical Fuzing |
| Haaland, Sterling | 39012 | 2050/ 2508 | E-O/IRCCM, Seeker Signal Processing |
| Hall, Floyd S. | 31505 | 3651 | FLIR |
| Ha11, James B. | 31408 | 5224 | A7E TRAM/Avionics Integration |
| Handler, Dr. George S. | 128 | 3818 | IR/EOCM NWC Coordinator |
| Harp, Daniel L. | 3262 | 7544 | IR Flares |
| Haugen, L. R. | 3157 | 3341 | Laser (System Design) |
| Helmick, C. N. | 3814 | 3076 | Pyroelectric Imaging |
| Hills, Dr. M. E. | 3854 | 2831 | Optical Material |
| Hillyer, Robert M. | 01 | 3409 | NWC Technical Director |
| Hintz, Robert T. | 3311 | 3949 | CO2 Lasers |

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|-------|---------------|---|
| Hoban, Fay | 3941 | 3364 | E-O Seekers (AGILE) |
| Hoffman, Herman J. | 3157 | 3730 | HEL, Optical Trackers |
| Holden, B. J. | 3134 | 2836 | IR Imaging/FLIR |
| Holloway, Harry | 3314 | | Holographic Elements, Displays |
| Holzer, William C. | 39051 | 2854/ 3262 | Optical Fuzing/IR Missiles |
| Hoyem, J. A. | 31408 | 5419 | TV/IR Sensor and Display/ Avionics System Inte- gration |
| Hueber, Werner G. | 315 | 2890 | Ant Target Screening/ Laser Radiation Analysis System |
| Hughes, Dr. Richard S. | 3815 | 3411 | Visual CM/Lasers |
| Hutcheson, L. D. | 3815 | 2470 | Integrated Optics |
| Iverson, Myren | 33 | | E-O Electronic Systems |
| Iwamura, Donald C. | 31503 | 2067 | Laser Designator/Range- finders |
| Jaeger, Harold L. | 3312 | 3965 | Optical Fuzing |
| Jeffers, Hal R. | 62201 | 6241 | HEL |
| Jeffries, Larry | 3941 | 3364 | IR Seekers |
| Jenkins, L. E. | 3125 | 3893 | CO2 Lasers/Laser Damage |
| Jernigan, James L. | 3815 | 2470 | Laser Technology |
| Johansen B. | 3156 | 3589 | Coherent Optics, Lasers |
| Jones, Ronald W. | 3153 | 3651 | NOGS/P-3 FLIRS |
| Jones, Thomas K. | 3941 | 2036/ 3364 | IR Measurements |
| Joyner, John W. | 3941 | 3364 | IR Physics/Seeker Design |
| King, Thomas F. | 3314 | 3082 | Optical Fuzing |
| Knipe, Dr. Richard H. | 3852 | 2904/ 2832 | |
| Koch, Albert | 3157 | 3341 | Laser Spot Trackers |

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|-------|---------------|---|
| Koiner, Carl W. | 6237 | 6337 | Optical Tracker Systems (INSTR) |
| Kovar, Joseph J. | 3153 | 3651 | E-O Seeker/Missile Seekers |
| Krausman, Richard D. | 6221 | 6262 | Optical Tracker (INSTR) |
| Kummer, Donald D. | 3941 | 2036 | IR Seeker Design/IRCM |
| Kunz, Kenneth M. | 3311 | 3082 | Optical Fuzing |
| Kvammen, Gary L. | 3921 | 2058 | Laser Technology |
| Kyser, Dr. David S. | 3813 | 2898 | E-O Materials, IR Materials, UV Materials |
| LaBaw, Kenneth | 3314 | 3007 | IR, Detectors/Optical Fuzes |
| LaBorde, Ray | 3331 | 2445 | Optical Fuzing |
| Lamb, John W. | 128 | 3818 | E-O Missile |
| Landau, Martin H. | 39031 | 2009/ 3262 | AIM-9L Technical Development |
| Leet, Henry P. | 31505 | 2505 | IR, Optics, Radiometry, Sensors Materials - TTCP |
| Leininger, Jack T. | 3151 | 3723 | Laser/Joshua Optical Test Facility |
| Livingston, David N. | 3901 | 3002 | E-O Systems/Modular Weapons |
| Loftus, Thomas E. | 3311 | 3948 | Optical Fuzing |
| Lowe, Gary D. | 3314 | 3131 | E-O Fuzes |
| Lundstrom, Dr. Eric A. | 3151 | 3583 | High Energy Lasers |
| Macomber, Bennie D. | 3333 | 2424 | Optical Fuzing |
| Mallory, Dr. H. Dean | 3834 | 2207/06 | Detonation Mechanics |
| Markel, Kenneth | 3621 | 3597 | IR Seeker Design |
| McBride, W. R. | 3854 | 2688 | UV/IR Materials |
| McCanless, Dr. William | 3151 | 3723 | HEL Effects |
| McKenzie, J. A. | 3311 | 3948 | Optical Fuzing |

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| NAME | CODE | PHONE | SPECIALTY |
|-----------------------|-------|---------------|--|
| Middlemiss, Edward R. | 3343 | 3553 | Optical Fuzing |
| Mills, John K. | 3941 | 3364 | IR Seeker Evaluation |
| Moore, Ken | 3244 | 7248 | Lasers, Integrated |
| Mott, J. G. | 31206 | 3893 | Sensors |
| Moulton, Marc | 3951 | 3611/12 | E-O Systems, CONDOR |
| Nadler, Dr. Mel | 3244 | 7317 | IR Flares, EOCM |
| Neal, Conrad L. | 0331 | 2471 | |
| Niccum, Edward B. | 3173 | 3551 | HEL |
| Nichols, Roy L. | 3311 | 3092 | Active Optical Terminal Homing |
| Oldfield, Charles R. | 3333 | 2433/24 | Optical Fuzing |
| Olsen, Allen L. | 38504 | 2603/ 2762 | IR Materials |
| Orton, Donald A. | 3943 | 2237 | IR/EOCM |
| Palmore, Patrick C. | 39103 | 2264 | IR Measurements/Laser Missiles |
| Peoples, J. | 013 | 3054 | |
| Piazza, Donald J. | 3341 | 3788 | Optical Fuzing |
| Pierce, Russell | | 3341 | Laser Technology |
| Pladson, Magnus K. | 3660 | 3369 | AIM-9/D/G/H |
| Rahn, Dr. John | 3815 | 2470 | IR |
| Ravsten, Milton | 3621 | 3597 | IR Seeker Design |
| Reed, Russell, Jr. | 3270 | 7334 | IR Flares, EOCM |
| Rehn, Dr. Victor L. | 3813 | 2898 | E-O, IR, and UV Materi- als/Modulable Filters |
| Ritchie, Milton | 3615 | 2047 | IR |
| Roberts, Richard A. | 3943 | 2237 | E-O Technology, ASMD |
| Saitz, Dorothy L. | 3943 | 2237 | IR Measurement Analysis |
| Scott, M. L. | 3815 | 2470 | Laser Technology |

| NAME | CODE | <u>PHONE</u> | SPECIALTY |
|------------------------|-------|--------------|---|
| Seibold, Joseph M. | 31501 | 2884 | FLIR |
| Shahan, Dale | 3542 | 5303 | E-O Technology |
| Shaffer, J. J. | 3818 | 3168 | Optical Components |
| Shawler, Gary L. | 332 | 3020 | IR and AO Fuze Systems Analysis |
| Shepheard, John | 3557 | 3575 | AIM-9D/G/H |
| Silberberg, George E. | 6231 | 6346 | Optical Tracker System (INSTR and IR Data Assessment) |
| Simpson, Carl E. | 3943 | 2237 | Holographic Elements, Displays |
| Smith, M. R. | 39042 | 3290 | WALLEYE/E-O Systems |
| Smith Stanley T. | 39403 | 3697 | IR Signature Analysis |
| Smith, Dr. W. H. | 31011 | 5578/79 | TV/IR Fire Control/ Avionics (A4-M ARBS) |
| Soileau, M. J. | 3818 | 2869 | Optical Material, HEL |
| Stanford, Dr. James L. | 3818 | 3306 | UV and IR Material (Optics) |
| Stenger, Mark | 3944 | 3711 | IRCCM, Signal Processing |
| Stedman, Robert | | | TV Tracker |
| Stephens, Larry M. | 3311 | 3948 | E-O Fuzes |
| Sumnicht, Howard I. | 3314 | 2870 | A/C IR Sig Analysis/ Support |
| Tanaka, W. H. | 3943 | 2237 | IR Radiation |
| Teppo, E. A. | 3151 | 3723 | Laser Technology |
| Thomas, Virgil | 4044 | 5293 | TV Camera/Trackers |
| Thompson, B. L. | 3943 | 2237 | Radiometry Measurements |
| Thornberry, Jack | 39043 | 2715 | Laser Weapons/BULLDOG |
| Totah, Nadium D. | 3620 | 3310 | CONDOR System |
| Turner, George | 3615 | 3115 | Integrated Optics |

NWC

| NAME | CODE | PHONE | SPECIALTY |
|------------------------|-------|---------------|--|
| Vanderbeck, John C. | 6242 | 6224 | IR Lasers, Optical Receivers |
| Vanbuskirk, L. G. | 3921 | 2369 | E-0 Trackers |
| Vollmerhausen, R. H. | 3944 | 3589 | IR Plume Simulators |
| Wagner, Dan | 3175 | 3589 | Color Displays |
| Walker, Aaron E. | 3341 | 3788 | Optical Fuzing |
| Webster, Dave W. | 3156 | 3588 | Extreme IR, LWIR |
| Webster, Willard P. | 3615 | 3100 | E-O Fuzes, IR Detectors |
| Wenzl, Bernard | 3924 | 3266 | Missile Seekers |
| Wheeler, D. H. | 31407 | 5419 | TV/IR Sensor and Dis- play/Avionics System Integration |
| Wilkins, Dr. Lowell H. | 39403 | 3697 | IR |
| Wills, James R. | 337 | 3940 | Optical Fuzing |
| Wilson, L. A. | 3158 | 3986 | A7E/TRAM Avionics Integration (Optics Tests) |
| Witcher, Donald H. | 3903 | 2863 | OWWG/ASMDS |
| Woodall, Norm | 3604 | 3419 | AIM-9D/G/H |
| Woodworth, William H. | 3951 | 3611/12 | E-O Seeker Design |
| Zulkoski, Thomas R. | 3266 | 3381/ 3874 | E-O Fuzes, Lasers |

NWSC

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| | | | , and the second |
|-------------------------|------|-------|--|
| NAME | CODE | PHONE | SPECIALTY |
| Benham, Harold L. | 3073 | 1894 | Detectors, Charge Coupled Devices |
| Bradley, Gerald S. | 502 | 1251 | Scattering |
| Dinerman, Carl E. (Dr.) | 5042 | 1992 | IR Sources; ECOM; Spectroscopy; Radiometry |
| Douda, Bernard E. (Dr.) | 5042 | 1603 | Infrared Decoys; IR Seekers; EOTAG |
| Hitchcock, Lyman M. | 502 | 1251 | Illumination Engineering |
| Johnson, Duane M. | 50C3 | 1282 | EOCM |
| Kemp, Jerry L. | 502 | 1251 | Systems Simulation |
| Lohkamp, Carl W. | 502 | 1358 | Target Acquisition; EOCM |
| Montgomery, David (Dr.) | 502 | 1358 | Atmospheric Physics; Aerosol Mechanics |
| Swinson, James A. | 502 | 1251 | Measurements |
| Tanner, John E. (Dr.) | 5042 | 1992 | Thermodynamics; IR Radiation |
| Webster, Henry A. (Dr.) | 5042 | 1747 | Spectral Measurements; Kinetics |
| Wildridge, John E. | 5041 | 1603 | Target Markers and Augmentation |

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|----------------------------|------|-------|--|
| Berlincourt, Ted (Dr.) | 420 | 4212 | Director, Physical Sciences Division |
| Condell, William J. (Dr.) | 421 | 4220 | Director, Physical Program; Lasers; E-O; EOTAG |
| Diness, Arthur (Dr.) | 470 | 4325 | E-O Metallurgy; Ceramics |
| Hargrove, Logan E. (Dr.) | 421 | 4222 | Modulators; Defectors Acousto-Optics |
| Horwath, Tibor G. (Dr.) | 220T | 4712 | Technical Director, Optical & Electro-Optical Systems & Applications |
| Lewis, David (Dr.) | | | Electro-Optics; Integrated Optics; Propagation |
| Nicolai, Van O. (Dr.) | 421 | 4219 | Optical Warfare Working Group; E-O Systems; Optically Pumped Solid State Lasers |
| O'Hare, John J. (Dr.) | 455 | 4507 | Engineering Psychology |
| Pilloff, Herschel (Dr.) | 421 | 4221 | Lasers and E-O . |
| Salkovitz, Edward I (Dr.) | 470 | 4407 | Director, Material Sciences Division; Material Hardening & Damage |
| Tolcott, Martin A. (Dr.) | 455 | 4506 | Director, Engineering Psychology Program |
| Weinberg, Elliott H. (Dr.) | 400 | 4101 | Director of Research |

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| NAME | CODE | PHONE | SPECIALTY |
|-------------------------|------|-------|-------------------------------------|
| Quelle, Fred W. (Dr.) | | 461 | Laser Technology; HEL; EOTPO |
| White, Matthew B. (Dr.) | | 461 | Laser Technology; EOTPO |
| Wood, Albert D. | | 461 | Gas Dynamic Lasers; Chemical Lasers |

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|----------------------|-------------|-------|------------------|
| Ivory, John E. (Dr.) | | 6069 | Laser Technology |

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(212) 264-8081

NAME CODE PHONE SPECIALTY

Rowe, I. 264-8081 E-O Technology

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(213) 795-5971

| NAME | CODE | PHONE | SPECIALTY |
|----------------------------|------|-------|-------------------------|
| Behringer, Robert E. (Dr.) | | | Laser Technology, EOTAG |
| Brandt, Richard G. (Dr.) | | | Integrated Optics |
| Gloye, Eugene E. (Dr.) | | | Human Factors, Displays |
| Lawson, Robert F. | | | FLIR |
| Marcus, Rudolph S. (Dr.) | | | Chemical Lasers |
| Soules, Jack A. (Dr.) | | | Laser Technology |

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(804) 444-xxxx AV 690-xxxx

| <u>NAME</u> | CODE | PHONE | SPECIALTY |
|-----------------------|------|-------|-----------------------------------|
| Colavito, T. J. (CDR) | 33 | 5771 | Ship Evaluation; EOTPO Contact |
| Gensler, R. L. (LCDR) | 632 | 5021 | EW Test and Evaluation |
| Meyer, J. R. (LCDR) | 721 | 5076 | FLIR/Laser Gun Fire Control |

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| NAME | CODE | PHONE | SPECIALTY |
|------------------------|------|-------|--|
| Akkerman, Art | 1232 | 8504 | Laser Measurements, Detectors Receivers |
| Armstrong, E.S. | 1153 | 7481 | E-O System Test Bed Aircraft Installations |
| Baxter, H. Bruce | 1232 | 8504 | Optical Surveillance, E-O Systems |
| Bird, Ron (LCDR) | 1230 | 8988 | Optical Countermeasures |
| Bittner, Alvah C., Jr. | 1226 | 8981 | Research Psychologist, E-O Systems/Human Factors |
| Blattel, Ray | 1232 | 8504 | Laser Instrumentation |
| Bondelid, M. (Dr.) | 3143 | 8904 | Optical Instrumentation, E-O Meteorology, E-O Chairman Meteorological Group-Range Commanders Council, Tri- Service E-O Sensor Atmospheric Optics Working Group |
| Bruns, Ronald A. | 1226 | 8981 | E-O Guidance/Control, Displays & Human Factors |
| Burge, Albert R. | 0160 | 9875 | ECM Project Manager, E-O Countermeasures |
| Cain, M. | 0141 | 8847 | Telemetry System T&E, E-O Displays |
| Caselton, L.H. | 3324 | 7491 | Threat Simulation/T&E, HEL Targets |
| Castelli, Alex | 1233 | 8504 | Spectroscopy |
| Chandler, W.E. | 1245 | 7368 | E-O System Evaluation |
| Clark, Bruce | 1233 | 8504 | E-O Data Processing |
| Dale, Lewis J. | 1234 | 8941 | E-O Weapon Guidance |
| Dennis, Steven E. | 1233 | 8504 | IR Warning Receivers |

| NAME | CODE | PHONE | SPECIALTY |
|--------------------------|----------|-------|---|
| deViolini, R. | 3253 | 8383 | E-O Meteorology, Climatology |
| Diehl, Robert C. | 0141 | 8847 | E-O Systems, HEL Project Manager, EOTAG |
| Drong, Mike | 1233 | 8504 | IR Measurement Systems |
| Dwelle, B.L. | 1153 | 8516 | IR Flare Production Lot Acceptance Flight Testing |
| Egli, R. | 3324 | 8487 | Threat Simulation/T&E, HEL Targets |
| Engel, J. | 4263 | 8681 | Optical Instrumentation |
| Fickenscher, D. (CDR) | 3250 | 7893 | Geophysics Officer |
| Francis, John | 0160 | 8975 | EWSSE Project Manager |
| Gardner, C.A. | 1221 | 7194 | HEL Applications/ Vulnerability Analysis |
| Godwin, Charles L. | 1233 | 8504 | IR Radiometry/Radiation Measurement |
| Hanssen, J. Scott | 1232 | 8504 | IR Measurement/Detectors |
| Harp, Ray | 1234 | 8941 | E-O Guidance & Data Links |
| Harris, Ernest | 0160 | 8975 | EW/ECCM Project Manager |
| Herleikson, Arne | 1155 | 8536 | Photogrammetry |
| Higginbotham, Keith F. (| Dr.)1245 | 7245 | HEL Systems Evaluation, Vulnerability |
| Holloway, H.G. | 1152 | 8516 | ATIMS Systems Operator, Maintenance |
| Jackson, Glenn | 4250 | 8681 | Photo Instrumentation |
| Johnson, M.D. | 1232 | 8988 | HEL Applications/Visual CM Analysis/Optical Signatures |
| Karney, James L. | 1232 | 8504 | Laser, LCM, LIDAR |
| Kent, Clarence A. | 1233 | 8504 | E-O Guidance, Simulation, Scintillation |
| Kingery, R.W. | 1174 | 7393 | Photogrammetry, Data Processing |

| NAME | CODE | PHONE | SPECIALTY |
|----------------------|--------|-------|--|
| Kinghorn, A.C. | 3143 | 8904 | Optical Instrumentation, E-O Meteorology |
| Knudsen, Ken C. | 1234 | 8941 | Missile System T&E (Air- to-Surface), E-O Seekers |
| Lea, D. | 3250-1 | 7893 | E-O Meteorology, Atmospheric Physics |
| League, R. | 1222 | 7194 | IR Measurements |
| Lillehaugen, Lyle E. | 1233 | 8504 | E-O Jammers |
| Loos, J. | 3143 | 8904 | Optical Instrumentation |
| Luttrell, Willie D. | 0140A | 8582 | Surface Weapons/Special Projects Chief Engineer |
| Mark, Richard A. | 1232 | 8504 | Laser Systems |
| Marson, Milton R. | 1230 | 8504 | E-O Systems |
| Mathews, Gary B. | 1232 | 8504 | IR Detectors, IR Atmospheric Transmission |
| Matusewicz, N.M. | 2201 | 7113 | E-O Weapons, EW Systems |
| McCluskey, James | 0160 | 8975 | ESM Project Manager, E-O Systems |
| McKeefery, Ray | 1232 | 8504 | Laser Designators, Optical Stabilized Platforms |
| Moroney, W.F. (CDR) | 1226 | 8981 | E-O Displays, Human Factors |
| Nies, R. | 1232 | 8504 | Laser Receivers, Data Processing |
| Noble, R. (LCDR) | 0132 | 8831 | ASRAAM Project Manager |
| Norton, J.M. | 3412 | 7310 | Optical Alignments and Calibrations |
| Nofrey, B.E. | 1245 | 7245 | HEL Systems Evaluation/ Vulnerability |
| Papcke, David E. | 1233 | 8504 | IR/UV Warning Receivers, EOTAG (Alt) |
| Pedigo, Richard | 0130 | 7063 | Missile Systems, T&E, E-O Systems |

| NAME | CODE | PHONE | SPECIALTY |
|-----------------------|------|-------|--|
| Pentico, R.R. | 1153 | 8448 | E-O Systems Flight Test Conductor |
| Phillips, C. | 3253 | 8383 | E-O Meteorology, Atmospheric Physics |
| Pignataro, Augustus | 1233 | 8504 | E-O Missile Guidance |
| Polley, Robert | 3143 | 8904 | E-O Meteorology, Optical Instrumentation, HEL Systems |
| Rackauskas, Raymond | 1232 | 8504 | Laser MDI |
| Rademaker, R.H. | 0101 | 7831 | Associate Project Management Officer |
| Rambo, N.H., III | 0134 | 7063 | Missile System T&E |
| Richardson, P. | 4250 | 7971 | Optical Instrumentation |
| Rose, Don H. | 1234 | 8941 | E-O Missile Guidance |
| Rosenthal, J. | 3253 | 8383 | E-O Meteorology, Atmospheric Physics |
| Rothgeb, J. | 1222 | 7194 | E-O Missile Guidance |
| Roush, Edward | 1151 | 8516 | O/R-HEL Feasibility |
| Sakazaki, Y. | 3151 | 8971 | Fiber Optics |
| Sandy, E.R. | 1154 | 7828 | E-O Systems Ground Support Equipment |
| Scheets, David F. | 1241 | 7236 | E-W Engineer, E-O Systems |
| Scudder, Robert | 0131 | 7379 | Airborne Weapons Chief Engineer |
| Smiley, Ronald | 0160 | 7836 | Threat Simulation/TAS |
| Standardi, F.W. | 1160 | 8413 | E-O Support Equipment |
| Stephenson, Andrew N. | 1232 | 8504 | E-O Systems, Advanced Optical Concepts |
| Sterken, J.R. | 3412 | 8148 | Optical Alignments and Calibrations |
| Stowell, Dan T. | 1232 | 8504 | IR Radiation Measurements |
| Studarus, Richard C. | 1232 | 8504 | Laser Receiver, E-O Processing |

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| NAME | CODE | PHONE | SPECIALTY |
|-----------------------|------|-------|--|
| Townsend, Charles L. | 1232 | 8504 | Advanced E-O Systems |
| Trowbridge, Taylor S. | 1232 | 8736 | Laser Systems, Physical Optics |
| Tsugi, K. | 1152 | 8516 | Expendable CM Dispenser Systems |
| Uros, Nicholas M. | 1233 | 8504 | UV Warning Receivers |
| Van Slyke, Noel E. | 1233 | 8504 | E-O Threat Simulation |
| Wadsworth, Jesse L. | 1233 | 8504 | UV Warning Receivers |
| Warnagieris, R.J. | 0160 | 7836 | E-O Threat Simulation |
| Watson, Carrol E. | 1233 | 8504 | HEL Systems T&E, IR Signatures, UV Warning Receivers |
| Weblemoe, J. | 3151 | 8971 | Optical Communications |
| White, Jack R. | 1233 | 8504 | IR Radiometry/Electronics |
| Wilke, Pamela S. | 1232 | 8504 | Laser Receivers, Detectors and Electronics |
| Willingham, J. Terry | 1233 | 8504 | UV Warning Receivers |
| Wilsey, Otis | 1174 | 7393 | Photogrammetry |
| Wilson, Frank C. | 3282 | 2340 | Hazard Area Control, E-O Systems |

STRATEGIC SYSTEMS PROJECT OFFICE DEPARTMENT OF THE NAVY WASHINGTON, D.C. 20376

(202) 697-8054 + Ext AV 227-8054

| NAME | CODE | PHONE | SPECIALTY |
|--------------------|--------|----------|---------------------------|
| *Gasparovic, R. F. | PSP | 3605 | IR |
| Giles, J. W. | PSP | 3611 | Optics |
| Gold, David | SP230 | 697-0401 | Fire Control and Guidance |
| *Irani, G. B. | PSP | | Optics |
| Rogers, David A. | SP2025 | | EOTAG |

*NOTE: Personnel above are employees of the Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland. Telephone: (301) 953-7100 at the extensions listed above.

SUMMER 1978 DIRECTORY OF NAVY ELECTRO-OPTICAL PROFESSIONALS 3rd EDITION

INTRODUCTION

This document is a revised edition of the Navy-Wide Directory of Electro-Optical Professionals compiled under the auspicies of the Naval Material Command (NAVMAT 08E/EOTPO). The Navy Electro-Optical Technology Program Office (EOTPO) is chartered by the Deputy Chief of Naval Material/Chief of Naval Development (CNM(D)/CND) to serve as scientific and technical advisor to the CNM on all Navy electro-optical technology. EOTPO has prepared this revised directory to facilitate and encourage coordination among key management and research professional personnel in the rapidly expanding technology of electro-optics.

The original edition of this directory was published in July 1974 in two volumes. Volume I listed Navy E-O professionals, and Volume II provided a preliminary listing of non-Navy professionals. The current revision is an update of Volume I. It lists Navy E-O professionals grouped by Navy Command or Facility. The EOTPO has made use of its representatives at Naval Commands and Laboratories in an effort to make this directory complete and accurate.

Reassignments, reorganizations, and retirements will degrade the accuracy of the directory. An errata sheet has been included so that recipients may note any changes, additions, or deletions and forward them to the EOTPO.

Manuscript submitted June 5, 1978.

Abbreviation Organization CEL Civilian Engineering Laboratory, Naval Construction Battallion Center (name change was: Naval Civil Engineering Laboratory (NCEL)) CNA Center for Naval Analysis CNM Chief of Naval Material CNO Chief of Naval Operations NAC Naval Avionics Center (name change was: Naval Avionics Facility, Indianapolis (NAFI)) Naval Air Development Center NADC Naval Air Propulsion Center NAPC (name change was: Naval Air Propulsion Test Center (NAPTC)) Naval Air Test Center NATC NAVAIR Naval Air Systems Command Naval Electronic Systems Command NAVELEX NAVSEA Naval Sea Systems Command NCSL Naval Coastal Systems Laboratory NESTED Naval Electronics Systems Test and

Center

Naval Intelligence Support Center

Naval Ocean Research and Development

Naval Medical Research and Development

Activity

NIC

NISC

NMRDC

NORDA

Evaluation Detachment

Naval Intelligence Command

Abbreviation Organization

NOSC Naval Ocean Systems Center

NOSC Bay Side Naval Ocean Systems Center

(name change was: Naval Undersea

Center (NUC))

NPGS Naval Postgraduate School

NRL Naval Research Laboratory

NSEC Naval Ship Engineering Center

NSRDC Naval Ship Research and Development

Center

NSWC/DL Naval Surface Weapons Center,

Dahlgren Laboratory

NSWC/WOL Naval Surface Weapons Center,

White Oak Laboratory

NSWSES Naval Ship Weapon System Engineering

Station

NTEC Naval Training Equipment Center

NUSC Naval Underwater Systems Center

NWC Naval Weapons Center

NWSC Naval Weapons Support Center

ONR Office of Naval Research

OPTEVFOR Operational Test and Evaluation

Force

PMTC Pacific Missile Test Center

SSPO Strategic Systems Project Office

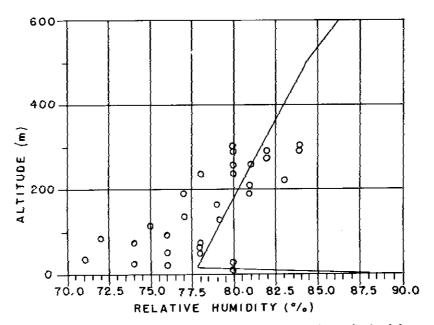


Fig. 7 — Comparison of the relative-humidity calculations obtained from the dry-blub and wet-buld temperature measurements of flight 51 (points) and the model estimates of relative humidity based only on shipboard observations (line)

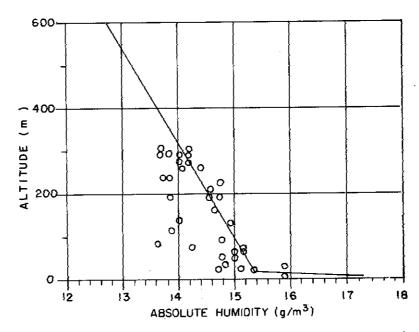


Fig. 8 — Comparison of the absolute-humidity calculations obtained from the dry-bulb and wet-bulb temperature measurements of flight 51 (points) and the model estimates of the absolute humidity based only on shipboard observations (line)

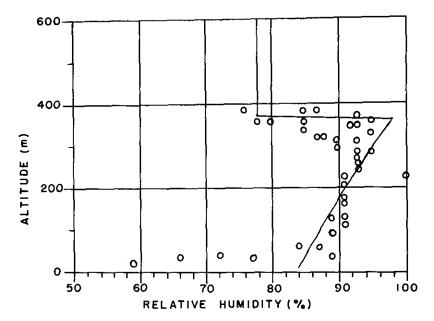


Fig. 9 — Comparison of the model estimates of a relative-humidity profile which predicted a dry upper air layer from surface measurements made at the time of flight 42 (line) and the kite-balloon measurements of relative humidity based on dry-bulb and wet-bulb temperatures (points)

Not all predictions are this reassuring however. Figure 10 is a plot of air-temperature measurement from flight 21 near the Gulf Stream. The air-temperature measurements (although the most basic and simplest of the measurements to make) seem to give absurd data. The problem results from the time required for the measurement, that is for the kite balloon to climb to altitude and then to be reeled back to deck height. Because the before and after calibration measurements of these data are accurate, the conclusion is that the atmosphere is changing rapidly. Thus during the 50 minutes required by the kite-balloon system to climb to maximum altitude and then to be reeled to the surface the assumption of a stationary atmosphere does not hold. Consequently a static model cannot duplicate these rapid changes in air-mass characteristics. It may well be that the model prediction is closer to a snapshot of the profile at one instant of time while the profile is changing from one form to the other than can be obtained from a measuring system which is slow relative to the time response of the nonstationary atmosphere.

The model predictions and the in-situ data taken over all of the flights of the 1977 EOMET cruise at the positions shown in figure 5 were compared as follows to allow the user some idea of the error bars on the model estimates. A calculation was made of the RMS error of the model predictions at 100 altitudes equally spaced below the maximum altitude obtained on the flight relative to the least-square third-order polynomial fits to the measurement data at the same 100 altitudes. This analysis shows that the worst-case air-temperature RMS error by the model was 3.7°C (for flight 3) but that the average RMS error for all flights was 0.7°C. A similar analysis shows that the model had an overall average RMS error

| | REPORT DOCUMENTATION | PAGE | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. | REPORT NUMBER | 2. GOVT ACCESSION NO. | |
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| 1 | TITLE (and Subtitle) | | 5. TYPE OF REPORT & PERIOD COVERED |
| | | | Interim report on a continuing |
| | MODEL FOR ESTIMATING METEOROLO | OGICAL PROFILES | NRL Problem |
| | FROM SHIPBOARD OBSERVATIONS | i | 6. PERFORMING ORG. REPORT NUMBER |
| ļ- | AUTHOR(a) | | B. CONTRACT OR GRANT NUMBER(a) |
| | , | ŧ | |
| | Stuart G. Gathman | 1 | |
| | | | |
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| | Washington, DC 20375 | ! | Program Element 63791N |
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| | Department of the Navy | ! | December 26, 1978 |
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| 19. | KEY WORDS (Continue on reverse side if necessary an | | |
| | | testing pard observations | |
| | | lary layer | |
| | Relative humidity Cloud | • • | |
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| 20. | ABSTRACT (Continue on reverse side if necessary and | d identify by block number) | |
| | A model is presented which estimates | s the vertical profiles o | of air temperature, relative humidity, |
| | and water-vapor density within the lowest | 2 kilometers of the ma | arine atmosphere. Inputs to the model |
| | are a subset of standard marine surface obs | | |
| | The 1977 EOMET cruise of the USNS Hay | es provided a set of ki | te-balloon measurements of air tem- |

perature, relative humidity, and water-vapor density together with standard marine surface observations throughout the North Atlantic Ocean and the Mediterranean Sea. The model estimates of the

(continued)

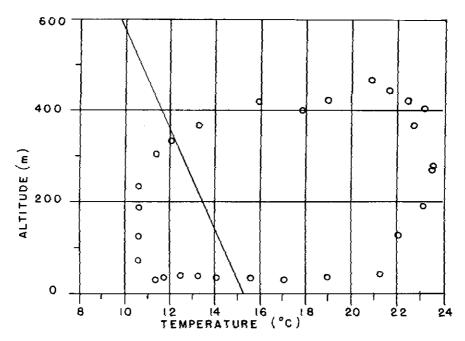


Fig. 10 — Example of an air-temperature profile (points) (obtained in a rapidly changing air mass from a sounding system that takes about 50 minutes to make a complete ascent and descent) that cannot be used to represent a stationary profile against which to test a static model (line). The data in this plot were obtained from flight 21.

in the relative-humidity estimates of about 20%. These errors however include not only inaccuracies of the model but all types of errors which might exist in this experiment, such as nonstationarity of the air mass.

The model test was also analyzed to see if the errors of the model depended on altitude. One would expect that, since the model is based on measurements at the surface, the model accuracy would decrease with altitude, so that the RMS errors between data points and model predictions would increase with altitude.

Table 1 shows the RMS differences between data points at the various measurement altitudes and the model predictions of the data at the same altitudes. These differences are averaged over all of the flights in 100-meter altitude bands. The RMS errors indeed tend to increase with altitude.

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Table 1 — Altitude Dependence of the RMS Errors of the Model

| Altitude Interval (m) | Number of | RMS Error | | | |
|-----------------------------|---|----------------------------|-----------------------------|---|--|
| | Observations in Altitude Interval | Air Temperature (°C) | Relative Humidity (%) | Absolute Humidity (g/m ³) | |
| 0-100 | 480 | 1.01 | 9.54 | 1.06 | |
| 100-200 | 296 | 1.21 | 9.71 | 0.94 | |
| 200-300 | 365 | 1.24 | 9.86 | 1.06 | |
| 300-400 | 341 | 1.34 | 11.93 | 1.40 | |
| 400-500 | 155 | 2.77 | 20.47 | 2.15 | |
| over 500 | 81 | 1.65 | 16.36 | 1.68 | |

GATHMAN

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APPENDIX

PROGRAM LISTING

```
FUNCTION RELHUM (Z, IQ, ISHIP, TALE, VAPLD)
C ***********************
С
  1.1DENTIFICATION NAME: RELAUM
   2.TITLE: METEOROLOGICAL PROFILE ESTIMATES FROM SHIP OBS.
   3. AUTHOR: STUART G. GATHMAN
   4.ORGANIZATION: NRL
   5.DATE: JULY 1977
   6.ROUTINES CALLED: ABORT, ALT, PALF, VAPPE, C10, ZZ ERO, QZ, QSTAR,
     THZ, THSTR, PMLNT, ZCON, SMIXE, TH, TEMP, VP, TABS, TCENT, LIMIT
      DIMENSION ISHIP (12), IPOG (14), IDAIZ (17), ICLR (6)
      IPW=1SHIP(1)
      ILCL=ISHIP(2)
      IASE=1SHIP (3)
      LAT=ISHIP (4)
      ICLHT=ISHIP (5)
      IDPT=ISHIP (6)
      ISSI=ISHIP (7)
      IWS=ISHIP(8)
      IV1S=ISHIP(9)
      ILWS=ISHIP (10)
      IIVIS=ISHIP(11)
      ICA=ISHIP(12)
      DATA(IFOG(I), I=1,14)/10,11,12,28,40,41,42,43,44,45,
                            46,47,48,49/
      DATA (IDRIZ(I), I=1, 10)/14,15,16,20,24,50,51,52,53,54/
      DATA (IDRIZ(I), I= 11, 17) /55,56,57,58,59,60,61/
      DATA (ICLR(I), l=1,6)/0, 1, 2, 3, 4, 5/
C
C CHECK FOR INDICATIONS OF FOG AND IF FOUND GO TO 100
С
      IF(IVIS.LE.94) GO TO 100
      IF(IIVIS.Eq. 1) GO TO 100
      DO 20 J=1,14
   20 IF (IPW.EQ.IFOG (J)) GO TO 100
C
C CHECK FOR INDICATIONS OF DRIZZLE AND IF
C FOUND GC TO STATEMENT NUMBER 300
      DO 30 J=1,14
   30 IF (IPW.EQ.IDHIZ(J)) GO TO 300
С
С
C CHECK FOR CLEAR WEATHER (IE NO INDICATION OF PREC.) AND
C IF FOUND GO TO STATEMENT NUMBER 600
      DO 40 J= 1.6
   40 IF (IPH. EQ. ICLA(J)) GO TO 600
C
    IP THE PROGRAM GETS TO THIS POINT WE MUST ABORT.
   50 CALL ABORT (Z,IQ,IDPT,IAT,RH)
      REL HUM=RH
      TALE=TCENT (IAT)
```

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```
VAPLD= 2. 165*RELHUM*VAPPR (TAIR) / (TAIK+273. 15)
       CALL LIMITS (RH, VAPLD, TAIR, IQ)
       RETURN
C
C
   THIS PART OF THE PROGRAM IS FOR TIMES OF FOG INDICATIONS.
  100 RELHUM=100.
       TAIR=TCENT (LAT)
       VAPLD=216.5*VAPPR(TAIR)/(TAIR+273.15)
  110 IQ=10
       IF (Z.GT. 400.) 1Q=6
       IF(2.GT. 1000.) 1y=2
       RETURN
С
C THIS PART OF THE PROGRAM IS FOR NON PRECIPITATION TIMES.
  600 IF (ILCL. EQ. 6) GO TO 700
       IP(ILCL. EQ. 4) GO TO 700
       IF(ILCL. EQ. 7) GO TO 700
      IF (IASD.LT.0) GO TO 800
1F(IASD.EQ.0) GO TO 900
C
C
    THE STABLE ATMOSPHERE
C
  777 CONTINUE
       IF(2.LT. 20.) GO TO 1000
       GO TO 1100
  THIS PART OF THE PROGRAM IS FOR UNSTABLE CASES.
   DETERMINE THE DEPTH OF THE SUPERADIABATIC LAYER.
  800 IQ=10
      DIF=ABS(FLOAT(IASD)/10.)
       IF(CIP.GT.0.5) GO TO 850
      ZSA=10.*DIF
       GO TO 870
  850 ZSA=11.92+9.69*ALOG(DIF)
C
C NEXT DETERMINE IF Z IS ABOVE OF BELOW THE TOP OF THE
C SUPERADIABATIC LAYER.
  870 IF (Z.LE. ZSA) GO TO 2000
C FOR ZSA < Z < ZH, THETA AND & ALE CONSTANT WRT ALTITUDE
C AND EQUAL TO THE VALUES DETERMINED AT Z=ZSA.
 1500 THSA=THZ (I1WS,1WS, IQ, ISST, IAT, ZSA)
       QSA=QZ (IINS, INS, IQ, ISST, IDPT, ZSA, IAT)
C
C FIND THE LIFTING CONDENSATION LEVEL FROM VALUES OF THETA C AND Q DETERMINED AT THE TOP OF THE SUPERADIABATIC LAYER.
```

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```
C
       ZC=ZCON(THSA,QSA,ZSA)
C
C DETERMINE THE CLOUD AMOUNT TO SEE IF THERE IS A
Ç
  TRANSITION ZONE EXISTING.
  1810 CONTINUE
       IF (ICA.LT.2) GO TO 1600
       ZH=ZC
       IF (Z.GE. ZH) GO TO 1700
  18 CO E=VP (QSA,Z)
       TAIR=TEMP (THSA, Z) - 273.15
       ESAT=VAPPR (TAIR)
       VAPLD=216.5*E/(TALR+273.1)
       RELHUM=100. *E/ESAT
       CALL LIMITS (RELHUM, VAPLD, TAIR, 19)
       RETURN
C
C
С
     THE IN CLOUD CASE
 1700 RELBUM=100.
       TALE=TEMP(THSA, Z) - 273. 15
       VAPID=216.5*VAPPR(TAIR)/(TAIR+273.15)
       1F(2.LT. 2000.) RETURN
       T2000=TEMP(THSA, 2000) - 273.15
       Q20Q9=SMIX (2,T2000)
      Q=Q2000+4E6/2++2
       ESAT=VAPPR (TAIR)
      E=VF (Q,Z)
      RELHUM=100*E/ESAT
      VAPLD=216.5*E/TEMP (THSA, Z)
       RETURN
C
C
C THIS PART OF THE PROGRAM IS FOR A CLOUDLESS CLOUDLAYER.
 1600 ZH=0.8*ZC
      IF (Z.GT. ZC) GO TO 1900
      1F (Z.LT. ZH) GO TO 1800
      DEL2=ZC-ZH
      TZH=TEMP (THSA, ZH)
      T2=IZH-0.006*(Z-ZH)
      ŲZH=QSA
      TZC=TZH-0.006*DELZ
      Q2C=0.76*SMIXR(2C,TZC-273.15)
      THSA=TH(TZ,Z)
      USA=QZH+ (QZC-QZH) * (Z-ZH) /DELZ
      GO TO 1800
C
    THIS IS THETA AND & CALCULATED FOR A SUPER A LAYER
C
 2000 X=Th2 (11 NS, INS, IQ, ISST, IAT, Z)
      R=QZ(IIWS,IWS,IQ,ISST,IDPT,Z,LAT)
      TC=TEMP(X,Z)-273.15
```

GATHMAN

```
VTEST=VP (8,2)
       VAPIST=VAPPR (TC)
       RELHUM=100. *VTEST/VAPTST
       TALE=TC
       VAPID=216.5*VTEST/(TAIR+273.15)
       ZO≈ZZERO (IIWS, IWS, 10)
       FL=FMLNT(105,11WS, ISST, 1AT, 10)
       FCN = (2 + 20) / FL
       IF (FCN-LE.0.03) GO TO 2010
       19≈19-2
 2010 CONTINUE
       CALL LIMITS (SELHUM, VAPLD, TAIK, 12)
       RETURN
¢
€
С
     STABLE ATMOSPHERE, Z> SHIP MAST HEIGHT.
 1100 IQ≈9
      CLEAS=FLOAT (ICLHT)
      CTOF=CLBAS+500
      IF (Z.GE. CTOP) GO TO 1105
      IF (Z.GE. CLBAS) GO TO 1104
      THS=TH (TABS (IAT) _{2}20.) + (Z-20.) + 2./(CLBAS-20.)
       QS≈SM1XR (20.,TCENT (IDPT))
      GO 10 1110
 1104 THS=TH (TABS (IAT) ,20.)+2.+(4-CLBAS) *.006
      QS=SMIXR (20.,TCENT (IDPT))
      GO TO 1110
 1105 THS=TH (TABS (IAT) ,20.)+5+.00001*(2-CTOP)
      QS=SMIXE(20.,TCENT(IDPT))*CTOP*CTOP/2**2
 1110 CONTINUE
      E=VE (QS, 2)
      TAIR=TEMP (THS, Z) -273.15
      ESA1=VAPPR (TAIR)
      VAPLD=216.5*E/TEMP (THS,2)
      RELHUM=100. *E/ESAT
      IF (BELHUM. LE. 100.) RETURN
      RELBUM=100.
      VAPID=216.5*ESAT/TEMP(THS,4)
      RETURN
C
E
Ċ
    STABLE ATMOSPHERE, ZC SHIP MAST HEIGHT.
C
 1000 THSE=TH(TABS(1AT), 20.)
      TBW=TH (TABS (ISST), 0.)
      USP=SHIXH(20.,TCENT(IDPT))
      QWT=.98*SMIXR(1.,TCENT(ISSI);
      THSA=THW+Z* (THSP-THW)/20.
      QSA=QWT+Z*(QSP-QWT)/20
      I Q= 10
      GO TO 1800
C
C
    NEUTRAL ATMOSPHERE CASE
  900 IQ=10
```

NRL Report 8279

Model for Estimating Meteorological Profiles From Shipboard Observations

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Atmospheric Physics Branch Ocean Sciences Division

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NAVAL RESEARCH LABORATORY Washington, D.C.

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```
1F(Z.LT. 20.) GO TO 975
      THSA=TH (TABS (ISST) .0.)
      QSA=SMIXR(20., TCENT(IDPT))
  950 &C= 121* (TCENT (IAT) -TCENT (LDPT) )
      IF(Z.LE.ZC) GO TO 1800
      GO TO 18 10
  975 TAIE=FLUAT (ISST) /10.
      QSEA=0.98*SMIX(0., TCENT(ISSI))
      QMAST=SMIX (20. , TCENT (IDPT))
      Q= (LMAST-USEA) +4/20. +QSEA
      E=VF(Q,Z)
      ESAT=VAPPR (TAIR)
      RELHUM=100. *E/ESAT
      VAPLU= 216.5+E/(TAIR+273.15)
      RETURN
   THIS PART OF THE PROGRAM TREATS LIGHT NON FREEZING PREC.
   OR DRIZZLE. RELATIVE HUMIDITY IS ASSUMED EVERYWHERE TO BE
   THAT OF THE SHIP.
  300 RELBUM=100.*VAPPR(TCENT(LDPT))/VAPPR(TCENT(LAT))
      GC TO 110
C
C
C THIS IS AN APPROXIMATION FOR THE CLOUDLESS "CLOUD LAYER"
  APTER HALKUS (1958)
 1900 RELHUM=78.
      19=7
      TALR=TEMP (THSA, Z) - 273-15
      VAPLD= 168.9*VAPPR(TAIR)/(TAIR+273.15)
      HETURN
   THIS PART OF THE PROGRAM IS FOR THE STRATUS CLOUD CASE
  700 CONTINUE
      IF(Z.LT. 20.) GO TO 1000
      CLBAS=FLUAT (ICLHT)
      CTOF=CLBAS+500
      IF (Z.GE. CTOP) GO TO 705
      IF (Z.GE. CLBAS) GO TO 704
      THS=TH(TABS(IAT),20.)+(Z-20.)*2./(LLBAS-20.)
      PC=TH(TABS(1AT), 20.) +2
      IC=IEMP(PC,CLDAS)-273.15
      QB=SMIXk (20., TCENT (IDPT))
      ¿C=SMIXR (CLBAS,TC)
      QS=QB+ (Z-20.) * (QC-QB) / (CLBAS-20.)
      GO TO 11 10
  704 THS=TH (TABS (IAT) ,20.) +2.+.006* (Z-CLBAS)
      GO TO 1110
  705 THS=TH(TABS(IAT),20.)+5.+.000001*(Z+CTOP)
      US=SMIXE (CTOP, TEMP (THS, CTOP) -273.15) *CTOP*CTOP/2 **2
      GO TO 1110
      END
```

Note: The Malkus citation on this page is Ref. 3 in the list at the end of the main text.

```
C
C SUBROUTINES AND FUNCTIONS FOR ODE WITH RELHUM PUNCTION.
C
Ü
      SUBBOUTINE ABORT (Z.IQ. IDPT, LAT, RH)
C
С
      THIS SUBROUTINE SIMPLY TRANSMITS THE SHIPBOARD MEASUREMENTS
      TO OTHER ALTITUDES AND DECREASES AND AS THE PREDICTIONS
С
C
      BECCME LESS ACCURATE.
ε
      DEWFT=FLOAT (IDPT)/10.
      PEMF=FLOAT (IAT) / 10.
      RH= 100 . * VAPPR (DEWPT) / VAPPE (TEMP)
      IQ≈y
      IF \{2.6T.100.\} IQ=6
      1F(Z.GT.500.)1Q=3
      IF (Z.GI. 1000.) IQ=0
      RETURN
      END
С
C
      FUNCTION ALT (P)
¢
      THIS PUNCTION COMPUTES ALTITUDE IN METERS FROM PRESSURE
C
      IN MILLIBARS. THIS FORMULA IS A PIT TO THE N.A.C.A.
      STANDARD LOWER ATMOSPHERE DATA: SMITHSONIAN MET.TABLES N63
¢
C
      LIST (1968).
      IF (F.LE. 1013) GO TO 10
      ALT=0
      RETURN
  10 IF(E.LE. 958.) GO TO 20
      ALT=9.09*(1013.-P)
      RETURN
  20 ALT=7850*ALOG(1021.38/P)
      RETURN
      END
C
      FUNCTION PALT(Z)
C
      THIS IS THE INVERSE OF FUNCTION ALT (P) WHERE ALTITUDE, Z
      IS IN METERS AND PALT IS THE PRESSURE IN MILLIBARS AT Z.
C
      IF(Z.LT.500.) GO TO 10
      PALT=1021. 38*EXP (-1. 2739E-4*4)
      RETURN
  10 PALT=1013.-55.*2/500.
      RETURN
      END
Ç
ت
      FUNCTION VAPPR (T)
C
      THIS IS AN APPROXIMATION TO THE GOFF-GRATCH TEMPERATURE,
£
С
      SATURATED VAPOR PRESSURE OVER LIQUID WATER FORMULA.
```

The Smithsonian tables cited are Ref. 10, and the List citation is Ref. 10.

```
IT WAS DESCRIBED BY BICHARDS (1971) AND WIGLEY (1974).
C
С
      IN THIS FUNCTION T IS IN DEG. C AND VAPPR IN MB.
      T4=1.0-373./(T+273.)
      R 1= 13. 3185
      R2=1.976
      R3=0.6445
      E4=0.1299
      HO= 1013.25
      VAPPE=EQ*EXP(R1*T4-R2*T4**2-x3*T4**5-R4*T4**4)
      RETURN
      END
      FUNCTION C10 (IWS, IIWS, IQ)
C
      THIS PUNCTION CALCULATES THE DEAG COEFFICIENT. IF WIND
C
      SPEED AT 10 METERS IS MEASURED, DEACONS SUGGESTED FORM
C
      IS USED: ROLL (1965), P. 161. IF NO WIND IS MEASURED A
      CONSTANT VALUE IS USED.
С
      IF (IIWS. NE. - 1) GO TO 10
      IQ=IQ-1
      C10=2E-3
      RETURN
   10 C 10=1. 1E-3+0.04E-3*FLOAT (AWS)
      RETURN
      END
С
      PUNCTION ZZERO (11WS, IWS, LW)
      THIS FUNCTION CALCULATES THE DYNAMIC ROUGHNESS, ZZERO
С
      IN METERS AS A FUNCTION OF WIND SPEED FOLLOWING CHARNOCK
C
      (1955) AND EXPRESSES FRICTION VELOCITY IN TERMS OF THE
С
      DRAG COEFFICIENT AND MEASURED WIND SPEED.
      IF (IINS. NE.-1) GO TO 10
      10=10-2
      ZZERO= 1. E-5
      RETURN
   10 ZZERO=C10(INS, IIWS, IQ) *3.33E-4*FLOAT(IWS) **2
      RETURN
      END
C
      FUNCTION QZ (IIWS, IWS, IQ, ISST, IDPT, Z, IAT)
C
      THIS FUNCTION CALCULATES THE MIXING RATIO AT ALT. Z IN AN
C
¢
      ATMCSPHERE WHICH OBEYS A LOG - LINEAR RELATIONSHIP:
      RCLI (1965), P. 237.
      TO=FLOAT (ISST) /10
      0=0.98*SMIXE(0.T0)
      USR=USTAR (IDPT, Z, IINS, INS, 18ST, 1V)
      ZO=ZZERO (LIWS, IWS, IQ)
      X= (Z+20) /20
```

The Richards, Wigley, Roll, and Charnok citations are Refs. 7, 8, 1, and 9 respectively.

```
FL=FMLNT (INS, 1INS, ISST, 1AT, 14)
       22=40+45E* (ALOG (X) +4.8*Z/FL)
       RETURN
       END
C
Ç
       FUNCTION THE (11WS, 1WS, 1Q, 13ST, 1AT, 2)
Ċ
C
      THIS FUNCTION CALCULATES THE POPENTIAL TEMPERATURE AT
C
      ALTITUDE Z IN AN ATMOSPHERE WHICH OBEYS A LOG - LINEAR
      RELATIONSHIP: ROLL (1965) .P.237.
      TO=273.15+FLOAT (ISST)/10.
      THO = TH (TO, 0.)
      20=22ERO (IIWS, IWS, IQ)
      X= {Z+Z0} /20
      PL=FMLNT (IWS, IIWS, ISST, IAT, 14)
      TSTAR=THSTR (IAT, Z, IIWS, IWS, ISST, 12)
      THZ=THO+TSTAR*(ALOG(X)+4.6*2/FL)
      RETURN
      END
C
      PUNCTION QSTAR (IDPT,Z,IIWS,IWS,ISST,IQ)
C
      THIS IS THE "FRICTION MIXING MALLO" USED IN QZ AND
      CALCULATED USING THE APPROXIMATIONS OF THE BULK AERODYNAMIC
      METHOD: ROLL (1965), P.252, 272.
      WA=SMIXE (10.,TCENT (IDPT))
      Q0=.98*SMIXE (0., TCENT (1881))
      CA=C10 (INS, IIWS, IU)
      FK=0.38
      USTAB=SURT (CA) * (UA-UO) /FK
      RETURN
      END
C
      FUNCTION THSTR (IAT Z.11MS, IMS, 1881, 19)
C
C
      THIS IS THE "PRICTION POTENTIAL TEMPERATURE" USED IN THE
      CALCULATION OF THE USING THE APPROXIMATION OF THE
      BULK AERODYNAMIC METHOD: ROLL (1965) P. 252, 272.
C
      TA=273.15+FLOAT (IAT) /10.
      TG=27J.15+FLOAT (ISST)/10.
      CA=C10 (INS, IIWS, IQ)
      FK=0.4
      THSTR=SURT (LA) * (TH (TA, 10.) -TH (TO, 0)) / FK
      RETURN
      END
Ç
      FUNCTION FULNT (1WS, 11WS, 15SP, 1AT, 1Q)
Ü
      THIS IS AN APPROXIMATION FOR THE MIXING LENGTH USING
      BOLL (1965), P. 144,252.
€
```

The Roll citation is Ref. 1.

```
IF (ILWS. NE.-1) GO TO 10
      FHLNT=-100
      IQ=IQ-2
      RETURN
   10 T0=273.+FLOAT(ISST)/10.
      TA=273.+FLOAT (IAT) /10.
      CA=C10 (IWS, IIWS, IU)
      X=T0*SQRT (CA) *0. 2646*FLOAT (IWS)**2
      Y=9.8*.38*(TH(T0,0.)-TH(TA,10.))
      PMLNT=-1.*X/Y
      RETURN
      END
С
C
      FUNCTION ZCON(TASA, RSA, ZSA)
C
      THIS FUNCTION CALCULATES THE LIFTING CONDENSATION LEVEL
Ç
      WHERE TASA IS THE POTENTIAL TEMPERATURE IN KELVIN AT ALT
C
      ZSA AND RSA IS THE MIXING RATIO AT THIS LEVEL IN G/KG.
      THIS FORMULATION IS AN EMPRICAL PIT TO DATA IN THE SHITHSONIAN MET. TABLES P.328.
C
      TSA=TEMP (TASA, ZSA)
      ESA=VP (RSA, 2SA)
      PK=1./.286
      X=EXP (FK*ALOG (TSA) )
      TC=732.02-150.41*(ALOG 10(X)-ALUG 10(ESA))
      TC=IC+7. 21* (ALOG 10 (X) - ALOG 10 (ESA)) **2
      TC=TC+273.15
      PZ= 1000 * EXP (-PK * ALOG (TASA/TC))
      ZCON=ALT (PZ)
      RETURN
      END
Ç
      FUNCTION SMIXE (Z,T)
C
С
      CALCULATES THE SATURATION MIXING RATIO IN G/KG AT HEIGHT Z
      AND TEMPERATURE T (C).
C
C
      SHIXE=0.622*VAPPR(T)/(PALT(Z)-VAPPR(T))
      RETURN
      END
С
C
      FUNCTION TH (T,Z)
Ç
Ç
      CONVERTS TEMPERATURE (K) TO POTENTIAL TEMPERATURE (K) AT
C
      ALTITUDE Z.
C
      TH=T*EXP (0.280*ALOG(1000./PALT(2)))
      TH=IH
      RETURN
      END
C
      FUNCTION TEMP(TE,Z)
```

The Smithsonian tables cited on this page are Ref. 10.

```
C
c
       CONVERTS POTENTIAL TEMPERATURE (K) AT ALTITUDE 2 (H) TO
       TEMFERATURE (K)
C
       TEMF=TE/(EXP(0.286*ALOG(1000./PALT(2))))
       RETURN
       END
C
C
       FUNCTION VP (R,Z)
C
C
       CONVERTS MIXING RATIO (G/KG; AT ALTITUDE Z (M) TO
       VAPCE PRESSURE (MB).
C
      VP=PALT(Z) *R/(.622+R)
      RETURN
      END
Ç
C
      FUNCTION TABS(1)
000
      CONVERTS AN INPUT TEMPERATURE INTEGER TO TEMPERATURE (K).
      TABS=273.15+FLOAT(I)/10.
      RETURN
      END
C
č
      PUNCTION TCENT (I)
C
C
      CONVERTS AN INPUT TEMPERATURE INTEGER TO TEMPERATURE (C).
С
      TCENT=PLOAT (I) /10.
      BETURN
      END
C
      SUBROUTINE LIMITS (RH, V, T, LQ)
      IF(RH-LE-65.) GO TO 10
IF(RH-LE-100.) RETURN
      RH= 100.
      GO TO 20
   10 RH=65.
   20 IÇ=IQ-4
      V=2.165*RH*VAPPR(T)/(T+273.15)
      RETURN
     · END
```

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MODEL FOR ESTIMATING METEOROLOGICAL PROFILES FROM SHIPBOARD OBSERVATIONS

INTRODUCTION

Large quantities of shipboard meteorological observations made throughout the world ocean over an impressive length of time are limited in nature and accuracy. But they provide a marine climatological data base which would be too expensive to duplicate to obtain other types of meteorological data subsequently needed but not specifically included in the data base. One example of subsequent need is the statistical characterization of detailed humidity and temperature profiles within the lowest 2 kilometers above the ocean surface. The relatively small group of radiosonde data taken by various weather ships and researchers is unfortunately sparse in both a geographical and a statistical sense. There exists therefore a need to invent a model which will provide an estimated profile of humidity and temperature when given the standard set of shipboard observables. Profiles obtained with such a model will be inferior to those observed directly by the use of radiosondes and are not intended to replace them, only to supplement them in areas where sufficient profile measurements do not exist.

The chief advantage is that profiles can be generated where no profiles have been measured and the results can be believed to within a certain degree of accuracy. One area of interest in which such a model could be useful is the transmission of optical energy over various nonhorizontal paths. Along these paths humidity estimates are valuable both for its effect on molecular absorption of optical energy and in its effect on the growth of aerosols.

This report describes such a model and a method and data to test this model. The test method can also be used on future models to ascertain their usefulness.

THE EMPIRICAL MODEL

The model divides the standard shipboard weather observations into essentially four cases:

- fog,
- light precipitation,
- heavy precipitation, and
- no precipitation.

Manuscript submitted August 31, 1978.

Characterization by the model of all but the last of these items is trivial in that present values on the ship are estimated to exist at higher altitudes. In the last case, however, more elaborate predictive methods are used.

An integer is delivered to the main calling program which gives a rough estimate of the quality of the particular value being calculated. When many assumptions are made, the quality integer (IQ) becomes low or even negative. Values of 10 are considered reasonable estimates.

The stability of the marine boundary layer is an important input to the model. The measure of this parameter that is available to the model is the air/sea temperature difference.

In the no-precipitation case the following distinct classes of profiles are modeled:

- Unstable atmosphere with cloud cover greater than 25%,
- Unstable atmosphere with cloud cover less than 25%,
- Neutral atmosphere with cloud cover greater than 25%,
- Neutral atmosphere with cloud cover less than 25%,
- Stable atmosphere with a stratus deck, and
- Stable atmosphere with no stratus deck.

The particular class of model chosen depends on the sign of the air/sea temperature difference, which determines the stability, and the level and/or type of cloud cover reported. The specific characterization of each of the profiles from any of these classes depends also on the specific values of the other shipboard observables.

In the modeling, potential temperature and mixing ratio are chosen as the particular meteorological pair of variables to describe the vertical thermal and vapor-loading characteristics of the atmosphere because of their insensitivity to adiabatic processes. One limiting feature of this model is that it is designed to describe only the layer of the ocean atmosphere at or below 2 kilometers; thus attempts to use the model outside of this limitation may result in severe errors.

The output of the model is relative humidity, absolute humidity, and air temperature (all quantities which are used directly in propagation calculations). In making these estimates, many conversions are required between various meteorological variables. Thus a number of conversion functions and subroutines are required by the model to convert easily from one set of parameters to another. These subroutines and functions (shown in the listing of the program in the Appendix) use for the most part standard meteorological relationships.

Unstable Atmosphere With Cloud Cover Less Than 25%

In modeling the class of profiles identified as unstable atmosphere with cloud cover less than 25% four levels are considered. Starting from the layer closest to the sea, they are

Since the area is clear (total cloud amount is less than 25%), then a transition layer is considered to start at an altitude of about 80% of the lifting condensation level. The transition layer starts at the top of the homogeneous layer. In the homogeneous layer both the potential temperature and the mixing ratio at all altitudes remain constant at the values obtained for the top of the superadiabatic layer.

According to measurements by Malkus [3], the relative humidity in the subsident non-cloudy cloud layer is 78%. Therefore in the transition layer the model slightly increases the potential temperature linearly and adjusts the mixing ratio so that 78% relative humidity is achieved at the altitude calculated as the lifting condensation level. Throughout the cloud-less cloud layer the model sets the potential temperature to that calculated at the lifting condensation level and correspondingly decreases the mixing ratio to keep the relative humidity constant at 78%.

Unstable Atmosphere With Cloud Cover Greater Than 25%

Figure 2 is a diagram of the same unstable atmosphere but with clouds. For altitudes below the transition layer the model is identical to that for the cloudless case. The model for the cloud case, however, keeps both the potential temperature and the mixing ratio constant with respect to altitude throughout the transition zone. Above the lifting condensation level when the relative humidity is 100%, the potential temperature remains constant but the mixing ratio is reduced just enough to keep the relative humidity at 100%.

The cloud layer extends from the lifting condensation level to about 2 kilometers, where the moist marine layer is usually capped by an inversion which divides dry warm air on top from the cool moist air of the marine layer. Above the 2-km level, temperature decreases at the standard lapse rate, and moisture is allowed to decrease rapidly toward the zero level.

Neutral Atmosphere

The neutral atmosphere, profiled in Fig. 3, is similar to the unstable atmosphere in both the cloudy and noncloudy conditions except that no superadiabatic layer exists. The temperature of the atmosphere is considered adiabatic from the sea surface up to the lifting condensation level. The potential temperature measured at the ship is used as the potential temperature throughout the lower atmosphere from the sea surface to the lifting condensation level in the cloudy case and up to the bottom of the transition zone in the subsident cloudless case.

The mixing ratio is interpolated linearly between values corresponding to relative humidity of 98% at the sea surface and that measured at the assumed mast height of 10 meters. Above 10 meters and below the lifting condensation level the mixing ratio is set constant to that measured on the ship.

- The superadiabatic layer,
- The homogeneous layer,
- The transitional layer, and
- The cloudless cloud layer.

The extent of each of these layers varies according to the individual input parameters. The unstable model is based on the description of the moist marine layer in the trade-wind zones sketched by Roll [1].

Figure 1 is a conceptual representation of profiles of the potential temperature θ and the water-vapor mixing ratio r for this class of atmosphere. The first layer above the ocean surface is called the superadiabatic bottom layer. In this layer the potential temperature and mixing ratio obey a log-linear formulation, with the defining parameters being related to the shipboard observations. The height of this layer above the sea surface is calculated by an empirical formula fitted to a series of measurements made by Brocks [2]:

$$\begin{split} Z_{\rm sa} &= 11.92 + 9.69 \ln(|T_{\rm air} - T_{\rm sea}|), \quad 5 < T_{\rm air} - T_{\rm sea}, \\ &= T_{\rm air} - T_{\rm sea}, \quad O < T_{\rm air} - T_{\rm sea} \leqslant 5, \end{split}$$

where $Z_{\rm sa}$ is in meters and $T_{\rm air}$ and $T_{\rm sea}$ are the air temperature and sea-surface temperature in degrees Celsius.

The meteorological parameters of θ and r at any altitude Z within the superadiabatic layer are computed from

$$\theta(Z) = \theta(0) + \theta_{\star} \left[\ln \frac{Z + Z_0}{Z_0} + 4.8 \frac{Z}{L} \right]$$

and

$$r(Z) = r(0) + r_{\star} \left[\ln \frac{Z + Z_0}{Z_0} + 4.8 \frac{Z}{L} \right].$$

In these formulas $\theta(0)$ and r(0) are the values of potential temperature and mixing ratio computed from measurements of the temperature of the sea surface. The variables θ_{\star} and r_{\star} are computed from

$$\theta_{\star} = \frac{\sqrt{C_{10}}}{0.38} \left[\theta(10) - \theta(0) \right]$$

and

$$r_{\star} = \frac{\sqrt{C_{10}}}{0.38} [r(10) - r(0)],$$

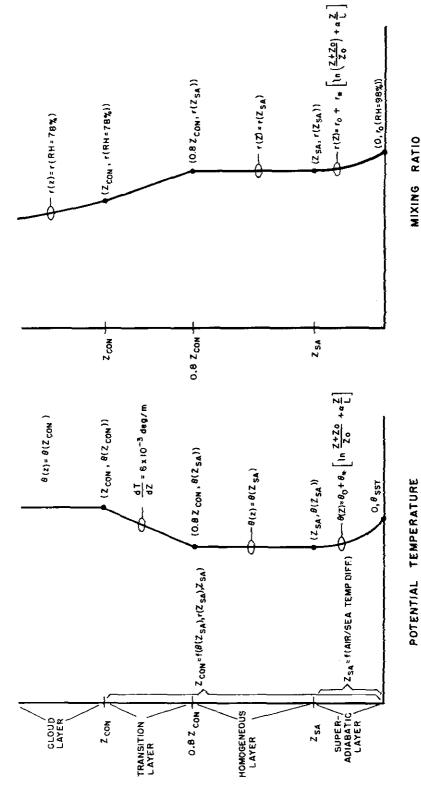


Fig. 1 — Profiles of the characteristic potential temperature θ and the water-vapor mixing ratio r for the unstable atmosphere with cloud cover less than 25%. Key points on these curves are set by appropriate shipboard observations. (Z_{con} is the lifting condensation level; θ (SST) is the sea-surface potential temperature.)

where

$$C_{10} = [1.1 + 0.04 \,\mu(10)] \times 10^{-3}$$
,

with $\theta(10)$, r(10), and u(10) being the values of potential temperature, mixing ratio, and real wind speed obtained at the nominal mast height of 10 meters. Values of Z_0 are obtained as follows: If the

real wind speed is measured, then

$$Z_0 = 3.3 \times 10^{-4} C_{10} u(10)^2$$
,

and if the real wind speed is not measured, then

$$Z_0 = 10^{-5}$$
.

Finally the values of the so-called stability length L are calculated from

$$L = \frac{-T_0 \sqrt{C_{10}} u(10)^2}{9.8 \times 0.38 \left[\theta_A(0) - \theta_A(10)\right]},$$

where the sea-surface temperature T_0 as well as potential temperatures $\theta_A(0)$ and $\theta_A(10)$ are in absolute temperature units. If values of the wind speed are not measured, L is set at -100 meters. When the relative humidity is to be estimated at an altitude less than Z_{sa} , then it is calculated by use of θ and r from these equations. If Z is greater than Z_{sa} , the values of potential temperature θ and mixing ratio r at Z_{sa} are used to estimate these same quantities at higher levels.

The height of the lifting condensation level $Z_{\rm con}$ must next be calculated from measurements available on the ship. The method used in this model is based on the solution of the equation for adiabatic lifting:

$$e/T^{1/0.286} = e_{sc}/T_c^{1/0.286}$$
,

where T is the temperature calculated at the top of the superadiabatic bottom layer, e is the vapor pressure calculated at the same point, T_c is the temperature at the condensation level, and e_{sc} is the saturation vapor pressure at the temperature of the condensation level. The potential temperature at the top of the superadiabatic layer is known, because both the temperature and the altitude are known. Also known is that the potential temperature remains constant with respect to altitude changes for adiabatic processes. Therefore at the condensation level the pressure p_c can be calculated from

$$\theta = T_c (1000/p_c)^{0.286} .$$

The model then uses the NACA standard low-level atmosphere to convert from pressure to altitude.

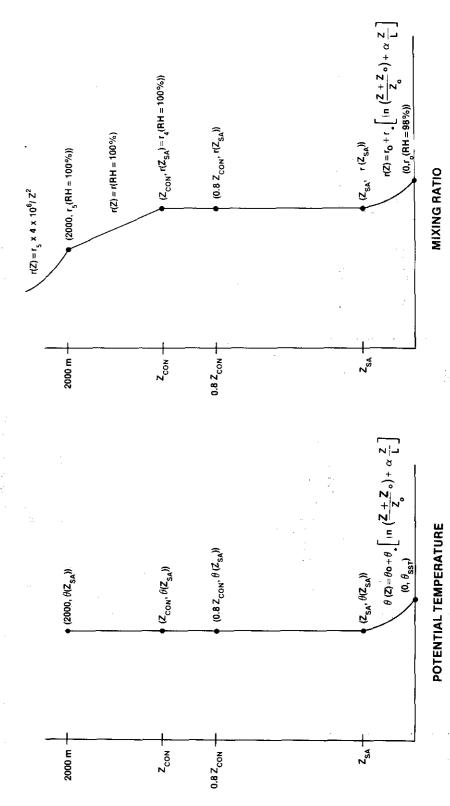


Fig. 2 — Profiles of the characteristic potential temperature and the water-vapor mixing ratio for an unstable atmosphere with cloud cover greater than or equal to 25%

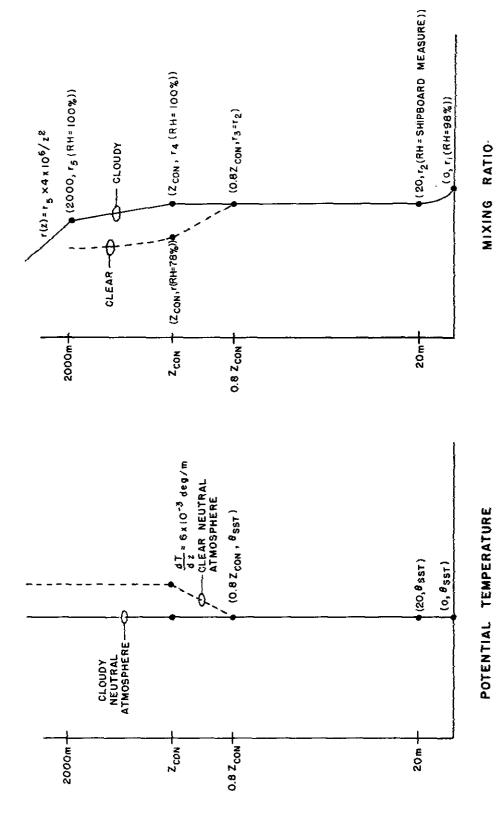


Fig. 3 — Profiles of the characteristic potential temperature and the water-vapor mixing ration for a neutral atmosphere. The dashed lines above 0.8 Icon apply when the cloud cover is less than 25%; the solid lines above 0.8 Icon apply when the cloud cover is 25% or greater.

Stable Atmosphere

The basis for the model estimates of the stable atmosphere is a series of tethered balloon flights made aboard the USNS *Hayes* during the 1975 fog cruise [4]. If a stratus deck is observed, the model constructs the following atmospheric thermal and water-vapor structure from four additional shipboard-measurable inputs: the sea surface temperature, the dew-point temperature and air temperature at 20 meters, and an estimate of the cloud-base altitude.

The potential-temperature structure is estimated in the following way and as shown in Fig. 4. The atmosphere is divided into four layers separated by four reference levels: the sea surface, 20 meters (the height of shipboard measurements), the cloud-base level (an input to the model), and the cloud top (assumed to be 500 meters above the cloud base). In the lowest layer a linear interpolation is assumed between the potential temperatures of the sea surface itself and the air at ship height. In the second layer a linear interpolation is made between the potential temperature at the 20-meter level to that at the cloud base level, which is assumed to be that of the ship plus 2°C. Over the next 500 meters an increase of 3°C of potential temperature is assumed. Finally above the cloud layer the potential temperature is allowed to increase at a small rate.

Similarly the mixing ratio is constructed in a piecewise linear fashion in the same four levels. In the lowest layer a vapor pressure of 98% of the saturation vapor pressure at the sea-surface temperature is assumed at the sea surface. The mixing ratio is then linearly interpolated between the mixing ratio r_1 calculated at the sea surface and the mixing ratio r_2 calculated at the mast height. When a stratus cloud is known to exist, then saturation is known to be achieved at the cloud base and therefore the mixing ratios r_3 and r_4 which are necessary for saturation are assumed both at the cloud top and at the cloud base. Linear interpolations are then made between these various fixed points. Above the cloud top the mixing ratio is allowed to drop off at a $1/Z^2$ rate.

The stable-atmosphere no-stratus-cloud profiles are identical to the stable-atmosphere stratus-cloud profiles except that the mixing-ratio profile is assumed constant from the shipmast height to 500 meters above the calculated lifting condensation level.

IMPLEMENTATION OF THE MODEL

The model is in the form of a Fortran function: RELHUM (Z, IQ, ISHIP, TAIR, VAPLD). The outputs of the model are the relative humidity in percent which becomes the functional value itself, the air temperature represented by parameter TAIR, and the water-vapor load of the atmosphere represented by the variable VAPLD. The integer output variable IQ is a quality index which is roughly related to the trustworthiness of a particular prediction as described above. The model requires only two inputs: the altitude Z (meters) at which the meteorological values are desired to be known and an integer array ISHIP which contains 12 integers from the standard shipboard weather reports.

The elements of array ISHIP are defined as follows:

is an integer between 0 and 99 (coded in accordance with Ref. 5) which describes the present weather situation;

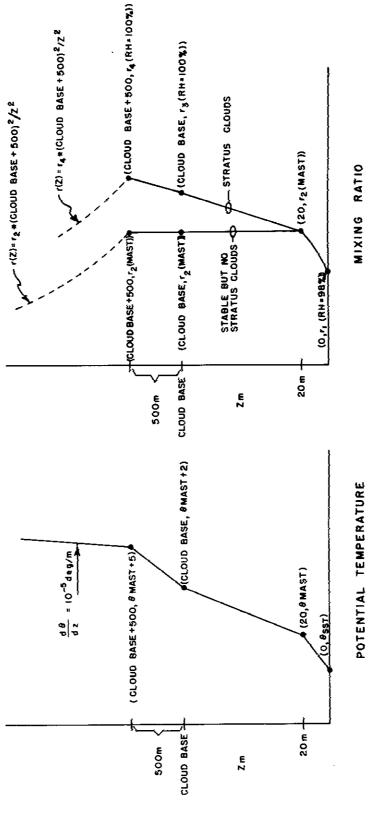


Fig. 4 — Profiles of the characteristic potential temperature and the water-vapor mixing ratio for stable atmospheres with a stratus-cloud deck and with no stratus-cloud deck

- ISHIP (2) is a parameter between 0 and 10 which describes the lower cloud types (ILCL);
- ISHIP (3) is a signed integer between -999 and +999 which is 10 times the air/sea temperature difference;
- ISHIP (4) is a signed integer between -999 and +999 which is 10 times the air temperature (IAT);
- ISHIP (5) is a noncoded integer which is the estimated height of the cloud base of the lowest cloud layer in meters (ICLHT).
- ISHIP (6) is a signed integer between -999 and +999 which is 10 times the dewpoint temperature at deck level (IDPT);
- ISHIP (7) is a signed integer between -999 and +999 which is 10 times the measured sea-surface temperature (ISST);
- ISHIP (8) is an integer between 0 and 99 which is the wind speed in knots;
- ISHIP (9) is a integer between 90 and 99 (coded in accordance with Ref. 5) which represents the visibility;
- ISHIP (10) is an integer which if equal to 0 indicates that wind speed was measured;
- ISHIP (11) is an indicator of the horizontal visibility at ship level, with 0 indicating that visibility was measured and 1 indicating fog;
- ISHIP (12) is a integer between 0 and 9 (coded in accordance with Ref. 5) which indicates the total cloud amount (ICA).

TEST OF THE MODEL

A test of the accuracy of this model within the marine boundary layer has been devised by comparing the model-produced estimates with measured profiles of temperature and water vapor. Field data suitable for this test was obtained from the EOMET cruise of the USNS Hayes during May and June 1977. During this cruise kite-balloon soundings were made, producing many observations within the marine boundary layer. Comparisons between the measured parameters of air temperature, relative humidity, and vapor density and those same parameters calculated from the model which used the appropriate standard shipboard measurements taken on the ship itself provide a useful test of any model of a boundary-layer profile.

The locations of the soundings are shown in Fig. 5 superimposed on the ship track, which covered portions of the North Atlantic and the Mediterranean Sea. Although the experiment provided over 1700 valid parameter sets obtained with the NRL boundary-layer sonde [6], the data are limited in duration at any one location and therefore do not form a climatologically complete set of measurements. It is nevertheless an excellent data base on

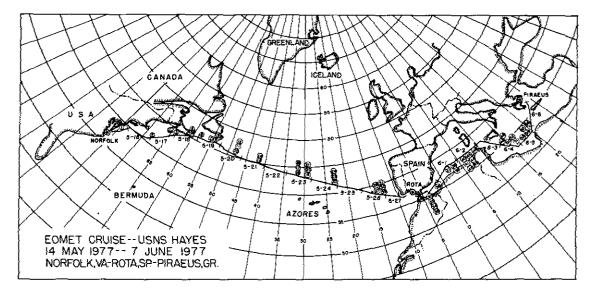


Fig. 5 — Cruise plot of the EOMET cruise of the USNS Hayes during May and June 1977. The circles represent positions during the track where kite-balloon profile measurements of air temperature, relative humidity, and water-vapor density were made.

which to test the model, because it does provide a wide variety of stability classes. The temperature measurements themselves are produced by dry and wet thermisters supported on the tether line to the kite balloon and ventilated by the relative wind. A solid-state pressure altimeter provides altitude information. Data are collected from these three channels and transmitted to the ship, where they are plotted in real time for the convenience of operators and digitally recorded.

The sensitivity of the system under real operational conditions allows both wet-bulb and dry-bulb temperatures to be measured to within an error band of $\pm 0.15^{\circ}$ C. The absolute accuracy of the radiosonde is checked before and after every kite-balloon flight by flying the measurement package at mast height and comparing these telemetered measurements with the shipboard measurements at mast height. Thus the calibration standard for the airborne units is the shipboard Cambridge model 100SM air and dewpoint temperature instrument. The altimeter is checked before and after each flight by observations of the pressure at the mast height, which eliminates the time variations of the atmospheric pressure from the altimeter. The operational accuracy of the altimeter is ± 14 meters at the surface but decreases with altitude. One advantage of the tethered kite balloon is that the same instrument package is used many times and the calibrations of the devices can be checked before and after each flight to make sure that changes have not occurred in the launch process or during the flight itself.

Part of the problem in obtaining an evaluation of the performance of the model is to include in the evaluation some of the nonhomogeneous characteristics of the atmosphere that might be present during a particular test. Sometimes at sea continuously recorded shipboard observations diverge significantly even during the time it takes to make a profile, which is the time for the kite balloon to climb to its maximum altitude and to return to deck

level. Consequently plots of all shipboard meteorological observations were made 6 hours prior to a flight and 6 hours after landing of the apparatus to aid in determining the stability of the shipboard observations. The first part of the test was to prepare from data for the middle of each flight a list of shipboard observables such as would be entered into any ship weather report. For every experimental observation of dry-bulb temperature, wet-bulb temperature, and altitude the model also would estimate air temperature, relative humidity, and vapor density at the same altitude, using as its input the list of shipboard observables. Differences between measured quantities and the estimated quantities represent information on the accuracy of the model.

Comparisons between the model predictions and measured data have been made for all of the flights flown during the 1977 EOMET cruise. In some cases the predicted profiles of air temperature, relative humidity, and water-vapor density were close to those measured. Figures 6, 7, and 8 are examples of good correlation. They were obtained from flight 51, which took place in the Mediterranean Sea on June 4, 1978. Each point in the figures refers to a sampling of the data transmitted continuously to the shipboard receiver and digitally recorded every minute throughout the flight. The scatter in the kite-balloon data is partly due to the instrumental uncertainties in both altitude and temperature.

Figure 9 is a plot of a particularly impressive and suprising prediction of a dry layer over the Mediterranean Sea which was both measured by the boundary-layer sonde and predicted by the model. Here both the model estimates and the measurements show that a sharply defined dry layer exists above 350 meters in altitude.

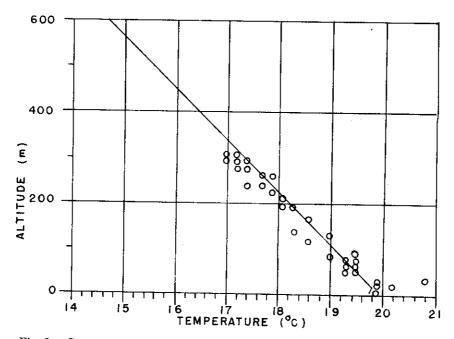


Fig. 6 — Comparison of the air-temperature profiles obtained from flight-51 kite-balloon measurements (points) and the model estimates obtained from shipboard observations at the time of flight 51 (line)